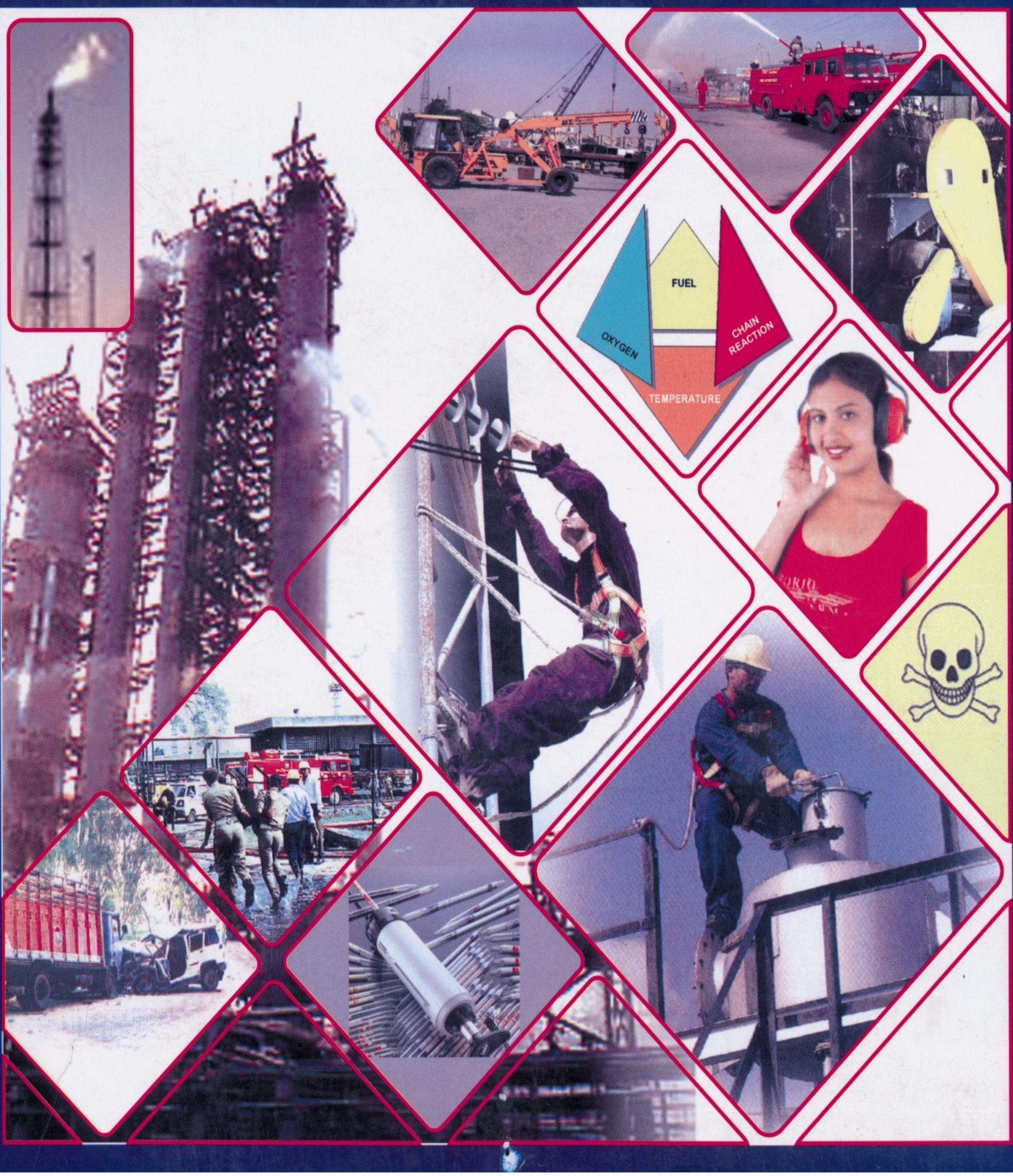
Fundamentals of Industrial Safety and Health

Dr. K. U. Mistry



Fundamentals of Industrial Safety and Health

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Disclaimer

The material in this book is prepared in good faith and carefully reviewed and edited. All care has been taken to give the latest position of law and to explain it from academic and application point of view. Safety measures suggested are mostly based on Indian Law, Indian Standards, self-experience and some International Standards, self-experience and some International Standards. However they should be applied after careful consideration of one's need, situation, environment, special circumstances and alteration, modification, addition or subtraction necessary as per standard engineering practice, safe control technology, good principles of safety philosophy, psychology, management and medical science. In no way the author, publisher or printer are responsible for any unknown error, omission or act in good faith in publishing this book.

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Foreword

The first edition of this book was published in June 1987. Sine then the syllabus of the Diploma Course in Industrial Safety has undergone Safety has undergone revision. Also, the Course has been re-designated in Maharashtra as Advanced Diploma in Industrial Safety from the academic year 1997-98. There is also a move to increase the duration of the Course to one and half years. If it materializes, the contents of the revised syllabus may further undergo some additions.

Furthermore, the last decide has witnessed a number of new safety related legislation being placed on the statue book. These legislation include 'Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989' as amended in 1994; 'Hazardous Waste (Management & Handling) Rules, 1989; Public Liability Insurance Act 1991; National Environment Tribunal Act, 1995; Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996'; Bio-Medical Waste (Management & Handling) Rules, 1998 and 'Central Motor Vehicle Rules, 1989' as amended in 1993 regarding road transportation of dangerous goods.

IS : 14489- 1998 as Code of Practice on Occupational Safety & Health Audit has provided good guidelines and uniformity in the subject of Safety Audit, again a statutory requirement.

The revised edition of the book is therefore overdue. The second edition of this book has taken care of the changes which have taken place in the syllabus and the statutes mentioned above and also updated the other data.

The book serves to provide in one volume the basic reading material required for pursuing the studies of the Diploma Course and should be found very convenient and useful by the students and faculty members alike without having to hunt for different sources of information. However, it does not mean that other references on specialised topics would not be required.

The author, Shri U.K. Mistry, is personally known to me for a number of years. Despite being a Senior Inspector of Factories with the Government of Gujarat, he is not depending upon the use of his statutory authority for achieving improvement in occupational safety and health conditions in factories. He is sincerely committed to improvement of knowledge and professional standards and promote a regime of self-compliance by management. I whole heartedly welcome this valuable contribution by Shri Mistry to the professional world. This book is a laudable effort to achieve this objective. I wish the book and its readers a great success.

K.C. Gupta
Director General
National Safety Council of India
Mumbai.

This book is dedicated to :

1. *All our genius forefathers and safety philosophers who have tried to save the mankind since centuries.*
2. *All scientists, engineers and authors who have contributed safety techniques, rules, regulations, standards, equipments and safety devices.*
3. *All legislators, judges, officials, unions, associations, employers, employees and professional who made safety laws, interpreted and implemented for the safety, health and welfare of all people.*
4. *All who have been and who are propagating for the cause of Safety and Health.*
5. *All who are prepared to work for Safety, Health and Environmental protection.*

Pre-conditions of Acquiring knowledge.

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You know that (knowledge) by leaning down, asking questions and serving the Gurus who are great philosophers and treasure of knowledge and who will give that knowledge to you.

& xhrk

Qualities of an Engineer

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An engineer should be fully qualified and capable of doing all types of construction work. None of his body parts should be defective or excessively short or long. He should be practitioner of 'Dhar', benevolent, unmistaken, active, mechanic, healthy, tolerant toward others' progress, mathematician, historian, truthfully and self controlling. He should be well conversant with drawing, design, time, weather and meteorology. He should be free from disease, laziness and seven evils of greediness, intoxication, gambling etc.

Preface

After the publication of the first edition of this book in 1987, twenty years have been passed. The book was welcomed and highly appreciated by all safety students, readers and professional people in industries who gave their feedback. An esteemed response was received from throughout the country by letters (still continuing) and personal inquires by the lovers of the book. This gives satisfaction and encouragement of the work done generously and sincerely. The main intent of writing this book Is to save life, environment, loss to men and materials and to prevent, control and mitigate hazards and accidents by creating safety awareness and preparing safety officers for this noble cause. Protection of human being is kept at the centre-point of the writing.

It is good that health and safety movement is taking momentum in this country, safety awareness at all levels is increasing, new statutes on safety law have come up during last twenty years and need of safety education and training is gaining more and more importance. It is made statutory in factories and the concept of Safety Officer, Factory Medical Officer and Industrial Hygienist and their work is recognized. The age-old factories Act, as it stands updated by its last amendment in 1987, and other safety statutes mentioned in this book, are the backbone of the whole safety law and requirements in our factories. In this perspective, the need of Safety Course and the need of such books are always justified.

The syllabus for the course of Post Diploma in Industrial Safety, as prepared by DGFASLI, Mumbai and approved by AICTE, New Delhi, in 1996, has been accepted by most of the State Governments including Gujarat. The Technical Examinations Board (TEB), Gujarat implemented this revised syllabus (curriculum) from the academic year of 1996-97. The Curriculum Development Centre (CDC), Ahmedabad revised and updated this curriculum in 2003 and TEB implemented it. This second edition of this book is entirely revised, renamed, enlarged and effort is made to prepare this handbook on this revised syllabus. It will certainly be useful to all the students and safety people in all the States. Chapters 7, 27, 28 and 29 are most useful to any person desiring to establish an industry in India as far as the statutory provisions are concerned though they are also subject wise given in most of the Chapters.

I have also gone through the syllabus of a new course – Master of Industrial Hygiene and Safety (MIHS), started from 3-9-1997, first time in India, at BVM Engineering College (now at ISTAR), Vallabh Vidhyanagar, Anand, Gujarat and some subjects of this course are also incorporated in this book.

This new edition includes following features :

1. The chapters have been rearranged.
2. Ample new material is added in all the chapters.
3. All new topics inserted by the revision of syllabus have been incorporated.
4. Figures, drawings and pictures have been added which were missing in the first edition.
5. An ‘Exercise’ is added at the end of each chapter. This is useful to PDIS and MIHS students for preparation of examinations.
6. Names of more reference books have been added at the end of each chapter.
7. Main ‘Index’ is expanded to find more headings quickly and new ‘Subject Index’ added at the end.
8. ‘Theme’ of the topics is maintained in the beginning of each chapter. It helps is grasping the whole chapter at a glance and to remember the contents.
9. Building of details is possible only when the foundation of fundamentals is sound. Therefore emphasis is given to clarify the fundamentals, concepts, definitions, principles, Indian Standards, Indian Law and essential requirements, rather than to increase a burden of more details. Looking to the inclusion of B.Sc. and Diploma students, this approach seems to be more useful. Aim of the

writing is maintained to prepare safety officials and professionals and not only the students. The book is equally useful to Inspectors of Factories or Directors of Industrial Safety and Health.

10. Presentation is kept plain, simple, lucid, exhaustive and easy to understand by the readers. The content depth is varying and limited by the size of the book.

While preparing this revised new edition, hundreds of books, standards and specifications have been referred. I have utilized my class-notes, lectures, reports, remarks, publications and materials from many known and unknown sources. Many books not referred but useful to students are also included at the end of each chapter. Abstract of experience of more than 35 years, has blended all such materials on the centerline of the prescribed course to deliver an intended product. Being busy with other works, it required some ten years for planning, thinking, continuous writing, rewriting and finalizing of this new edition.

To explain the target area of safety work, ample statistics is given in Chapter 5 and in other chapters with relevant topics, for which the sources of Labour Bureaus, Shimla, Office of the CIF, Ahmedabad, NSC (USA) publication – Accident Facts, 1997, Loss Prevention News, Some Indian companies and news reports are gratefully acknowledged.

Hazard control technology has expanded much and will continue to expand. New plants are coming with built-in safety feature but owing to their complexity and automation, a job of a safety officer is becoming more tough to understand and identify the hidden hazards and to suggest their remedial measures. The complex plants may be vulnerable but the application of accident prevention philosophy, techniques and safe operating procedures envisaged in this book will go a long way in preventing accidents.

However the fact remains the same in developing and under-developed countries that safety status in more than 90% small and medium scale factories is still poor, below standard and needs much effort of safety officers to improve it. Thus, despite of the latest hazard control measures in a very few companies, the vast area is still open to work hard for safety and health problems in majority of the factories. About 3 million small scale industries are located in India. This book will certainly help to all such industries in this regard to understand the subjects of safety from fundamentals to the as-on-today status and to select and apply hundreds of remedies to our present problems. Systematic basic approach leading to the details, step by step, reinforced with the statutory provisions, Indian Standards and accident case studies will mould our safety professionals to help the industries to fulfill their legal requirements.

I cannot conclude without thanking my colleagues, who helped me directly and indirectly, Shri Sharadbhai Shah, Shri Partha Sengupta and Shri Kishor Kanzariya who computerized a voluminous manuscript, Shri D.H. Patel, Charted Engineer, Safety Professional and a Competent Person, Shri HS. Dave, Deputy Director of Industrial Safety and Health Consultant and General Surgeon, Dr. Jagdashbhai D. Shah, Occupational Health Consultant, Shri Amit D. Parikh, Lecturer at MIHS and Shri S.H. Munshi, Lecturer for providing various standards, specifications, examples and photographs and discussing many safety matters.

I am also thankful to many manufacturers and suppliers of personal protective equipments whose published photographs and figures have been utilized in this book.

How can I forget to express my deep gratitude to Shri K.C. Gupta, Director General of National Safety Council, India for writing Foreword and increasing the beauty of this book.

Nothing could have been possible without the tolerance and sacrifice of my family members as I could not spare sufficient time for them. Words are insufficient to express my debt of obligation towards them.

At the end, I would like to say that this is not the end, because, the process of acquiring and spreading knowledge has no end and it is the best habit as per our Indian philosophy.

O;lukfu lfUr cgq'k%] O;lu};eso dsoy O;lue~ A
fo/;lH;lua O;lua ;n~ ok gfjiknlsoua O;lue~ AA

Habits are many but only two are important: a habit of learning and a habit of serving the lotus feet of the God. This is the only conclusion.

Ahmedabad
15th February 2008 ***Dr. K.U. Mistry***

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CHAPTER – 1

The Concept of Safety

THEME

The first requirement before going through any book on Industrial Safety is to properly understand the Concept of Safety.

The concept of safety can well be conceived by understanding the struggle of Dead Vs. Live resources, Health Vs. Wealth and Industrialization Vs. Accidents.

1. DEAD Vs. LIVE RESOURCES

All-resources in this world can be classified in two parts only-Dead and Live Resources. All elements, compounds, minerals, metals, non-metals and all material things that are not alive, are called Dead Resources. All living creature including human being are live Resources. All dead resources are invented, produced and used by the live resources. If there is no live resources, there is no important of any dead resource. However, haphazard generation and use of dead resources have created a great threat to the live resources and therefore a question of safety has been arisen.

Now, a question arises – Out of dead and live resource, which is more important? Out of man and machine who is more important, machine or its creator a man? All raw materials to be processed in industries are dead raw materials with few exceptions like killing of animal or generation of live culture for fermentation etc. But most of the raw materials like metal, non-metal, important to run the industry for producing goods and services needed for the mankind. But can they alone run the industries? And after all they are for whom? They are produced and processed for whom? And by whom? The simple reply brings before us a man-the live and real resources for the world, industry and any activity. It is the man behind machine who operators it and who has made that machine and who also repairs and maintains. it is the human being only who has invented the dead raw material, their uses, machines processes products and utility for various purposes. If he is absent, the dead raw material are of no use. Therefore it is obviously inferred that the live resources, the human beings, are more important than the dead resources. Therefore we must pay more attention on these live resources. That is why the Safety, Health and Welfare of people are considered to be of prime importance and we must never forget them. The dead raw materials are not for the destruction of mankind. The wise people always oppose such misuse. The contact of man and machine, man and material, man and environment must be safe.

We are also worried that hazards are being shipped overseas. Dangerous raw materials and discarded plants of developed countries-because safety and health conditions are laxer here? These dangerous dead resources are causing threats to the live resources that have to run these plants.

Now days the importance of human resource is increasing worldwide. That is why we found Human Resource (HR) Department in industries. The basic object of HRD is to pay more attention and refine human resources. These human or live resources can be developed (refined) only when they are protected from the dangers of dead resources. This protection is nothing but the Concept of Safety.

2. HEALTH Vs WEALTH

The most important live resource is a man. If we concentrate on this 'man' what is more important? His Health or Wealth? The simple reply is both', because men want both. But the well-known maxims like health is wealth, sound mind in a sound body, 'kjhjek|e~ [kyq /keZlk/kue~] point out that the health is more important Yet it seems that the people take more care of wealth than the health. Many lose their health and life in a race for the wealth. The growing industrialization is also a race for the wealth. It has brought many hazards and threats to its creator a **man** himself? Health of people is day by day worsening and it seems that the wealth is constantly challenging the health.

The great philosopher E.E. Schumacher explains, 'In the excitement over unfolding of his scientific and technical power, modern man has built a system of production that ravishes nature and type a system of production that ravishes nature and type of society that mutilates man. The development of production and the acquisition of wealth have become the highest goals of the modern world in relation to which all other goals have come to take second place.

The mad concept of wealth and growth is explained by Jay Forrester in the following words:

If the developed countries continue to increase their demand for material goods as hither to, life on earth may come to a horrible end around 2070, owing to either massive starvation or fatal levels of pollution, for the affluent countries are spending themselves to destruction in a mad pursuit of growth that has ceased to have any meaning for them.

In an Agenda of Science for Environment and Development into 21st Century, Maurice F. Strong, Secretary General, UNCED writes – "Mankind is in the process of over whelming nature. And there is a penalty we must all pay for our domination of the natural world upon which we have always depended absolutely…. We are forced more and more to take up the burden of being responsible for its survival forever…. Instead of being a minor guest at the Earth's table. The human species is on the way to consuming the whole feast and we are in danger of being forced into a partnership with nature to provide the feast forever. We must not turn the gift of nature into a Faustian bargain."

Justice K. Ramsawami of our Supreme Court, begah his landmark judgement (1995) on asbestosis with the following words;

"Occupational accidents and disease remain the most appalling human tragedy of modern industry and one of its most serious forms of economic waste"

World Environment (1985), a a brochure published by Lok sabha Secretariat, New Delhi, in 1985, throws much light on environmental problems. Its introductory opening paragraph runs as under.

"Over the course of ten thousand years humans have successfully learned to exploit ecological system for substance. While ecological system are supple, they can snap viciously when bent too far. The land's ability to serve human ends can be markedly and sometimes permanently snapped. Humans out of ignorance, short-sightedness, greed or desperation have polluted air and water, undermined the productivity of the land through accelerated soil erosion, creeping deserts, increased flooding and declined soil fertility. They thus destroy the basis of their own livelihood and they violate the limits of natural systems. The principal victims of these trends are the world's poor, who, in their quest for food and fuel, are often, forced by circumstances beyond their control to serve as the agents of their own undoing".

Worldwide environmental issues mentioned in this brochure are :

1. Climatic Changes.
2. Risks to Ozone Layer.
3. Acid Rain.
4. Pollution of World's Oceans.
5. Desertification.
6. Loss of Tropical Forests.
7. Soil Loss, and
8. Depletion of Genetic Resources.

The present status on these issues in India is dissatisfactory as evident from the following report.

The State of India's Environment 1984-85, i.e. the Second Citizen's Report published by the Centre for Science & Environment, New Delhi, describes how our land, water, forests, dams atmosphere, habitat, people, health, energy and living resources are deteriorated and what the overall effects on our national environment are. It says due to 50 – fold increase of mineral production in last 30 years, several million hectares of good crop and forest lands have been destroyed by mining operations and hundreds of villages depopulated. The satellite data confirms that India is losing 1.3 million hectare of forests a year, nearly 8 times the annual rate put out by the forest department. India uses @ 1 lakh ton of pesticides annually of which 70% is banned by western countries. A WHO study, which anlaysed food samples across India, found that 50% were contaminated with pesticide residues and 30% exceeding permissible limits.

Thousands of workers die every year due to occupational diseases (most of which remain unreported), the gravest being caused by various types of dust from slate pencil factories, mines, thermal power stations, fertiliser and pesticide factories, textile and sugar mills, asbestos, tobacco & wood factories and thousands of toxic chemicals from variety of chemical factories.

'Down to Earth' report of 15-10-1996 prepared by Carten Brendon and Carston Homen of the World Bank says that every year Indian suffers a loss of Rs. 34000 crores due to loss of environment which results from the process of industrial growth ! It clearly speaks that in 23 major cities of India, the air pollution is much higher than the maximum permissible level, and suspended solids in four major cities are 3 to 4 times more than WHO standards. CO, SO_2, NO_x and Hydrocarbons are killing thousands of people every year. Some 3 crores man-days are lost every year due to the effect of polluted water. The ground water level is dangerously decreasing. Some 40 lakhs people get affected due to air pollution in Delhi alone. Serious diseases are constantly increasing and the health of people is really in danger due to such chemical effects.

'Green –peace International report' published in 'The Times of India' on 10-12-1996 says that some three million small units throughout India contribute about 45% of industrial pollution. It said that @ 50% of the chemical storage tanks were found in bad condition with over 61% units having no scheduled maintenance system for storage tanks. Almost 80% workers were not using personal protective equipment. Alarm systems were visible in 18% units and written procedures were found in 17% unit only. There was a shortage of qualified, managerial and supervisory staff in 45% units surveyed. The Green-peace warned about continuing use of mercury cell method (instead of membrane cell technology made compulsory since 1986) in Chlor-alkai industries. Mercury is highly poisonous to human nervous system. It also spelled out dangers of exposure to Organochlorines, which might lead to fatal deaths and spontaneous abortions and cancer to industrial workers. A number of synthetic chemicals including Organochlorines, Organophosphorous etc. every in the tiniest amount could lead to fall in fertility and changes in sexuality in males and females, it added.

Atlanta Report published in Atlanta Journal on 18-11-1992, gives warning with the signatures of 1175 Scientists (of which 100 are Noble Prize Winners), as under.

Due to the dangerous effects of environmental pollution, more than 20% trees and plantation, animals and other living creature will die in near future. If no remedial measure will be taken, ice-mountains at North Pole will melt due to green house effect, tide will come in number of seas, more and more cities and villages will float in sea waters, lakhs of acres land will sink in water and food grains and other commodities will be carried away by the tide waters, this warning will prove true before the year 2010, the scientists added.

Glowing Girls ! – An oldest report says that in Switzerland girls were doing the jobs of painting radium on clock dials. While doing so, unknowingly, they were just holding, the radium needle between their lips. After a long time it was observed that their eyes were actually glowing during night as radium dial glows. They were looking fine because of their shining eyes and they were preferred for marriages. Unfortunately, they began to die prematurely at an early age. As a result, the use of radium was prohibited to paint clock and watch dials.

Report of Indian People's Tribunal submitted to the Government of Gujarat and GPCB is published. It discloses a study of 25 villages near 56 km long canal carrying polluted water from Vadodara to Khambhat. It indicates the increased level of metal deposition on food-grains (crops in lakhs of hectares of land in these villages. Reported metal levels in food grains are given in **Table1.1**.

Table 1.1. : Metal Level in Food grains

Food-Grain	Metal	Normal level (mg)	Increases level (mg)
Wheat (1 Kg.)	Hg	1.10	2.40
	Fe	6.70	41.30
	Cd	2.40	21.30
	Ni	1.0	2.10
	Zn	99.4	367.4
	Cr	1.10	3.40
	Cu	76.30	89.80
	Ca	5111	6017
Pigeon Peas (bean) (Tuver Dal) (1 Kg.)	Pb	1.20	4.20
	Ni	1.30	61.50
	Zn	9.90	38.20
	Cr	1.30	8.80
	Cu	1.10	2.60
	Fe	4.80	26.60
Maize (Makai) (1 Kg)	Cu	1.90	16.30
	Cr	1.10	3.90
	Zn	108.70	318.10
	Ni	2.10	63.40
	Pb	1.30	3.30
	Cd	2.10	8.90
	Fe	8.20	21.70
Bajara (1 Kg)	Cu	136.20	204
	Cr	2.0	63.20
	Zn	262.80	427.20
	Ni	1.10	3.20
	Pb	1.30	2.30
	Cd	2.20	10.70
	Fe	2.80	25.70

Such heavy metals enter the body through food and attack liver, kidney, intestine, bladder, brain and the blood circulation. This seems to be the main cause of increasing many disease including cancer (News 12-06-2000).

Such open canal should never be permitted Animals can drink such water. Polluted water must be discharged through a closed pipelines. Farmers should be advised not to use such wate.r penal actions should be taken against the sale of such food-grains.

It is reported that Mahi and Mini Rivers in Gujarat were severely polluted 30 years before due to 200 poisonous factories in Vadodara area. In 1969, Gujarat Government had constituted a committee to inquire into this matter. As a result 56 km pipeline was laid down between Vadodara and Khambhat. Reports of NEERI, Nagpur and MS University, Vadodara, both had told that the ground water in Bajava Village was not remained potable. The same is the case at many places near the chemical factories.

30 villages on riverbanks in Gujarat drink fluoride rich salty water and invite many diseases (News 26-12-02).

The water of Ganga river is highly polluted. 21 big cities near ganga throw 140 crore liters untreated sewage water daily into it. Thousands of factories throw poisonous chemicals into it. This causes 88% pollution of Ganga. Ganga Action Plan of Rs. 1000 crore has failed. Many dams on Ganga river has restricted its flow. As per CNN- IBN report, name of Ganga has been added in the highest polluted five big rivers of the world. (News 19-02-2008).

The water of Yamuna river is so polluted that it is of no use for any purpose. The Central Pollution Control Board has published this fact in their report (News 17-02-97).

Grampanchyats in Andhra Pradesh ordered the public to take bath at 4 days and to wash cloths at 10 days, otherwise there will be a fine Rs. 500 ! (News 3-02-03).

UNICEF published a report that if planning for proper preservation of water will not be made; people will fight for a drop of water in coming 20 years. (News 29-04-20002).

Vadodara, Bharuch, Surat and Vapi are named as most polluted areas where environment including water, air, fish, fruits and crops is badly damaged. The Golden Corridor has been blackened, it is added (News 31-10-2000).

"Stress and pollution render more men infertile" was the headline of the Times of India, Ahmedabad, of 6th June 2000. "Incidence of infertile males seeking In-Vitro Fertilization (IVF) the world over has risen up to 50%" it was reported. Modern lifestyle – over exposure t heat and pollution, stress, habit, tight clothing, unsafe sex, tobacco chewing and infections – shown as the main reasons. (News 06-06-2000).

Peoples Training & Research Centre and Vyavsayik Swasthya Suraksha Mandal, Vodadoar,a has published in April 1999, an appeal letter to celebrate '28th April as 'The World Workers Remembrance Day'. It quotes some WHO figures as under :

Worldwide 12 crores accidents occur every year wherein 2.20 lakhs workers die. Some 16 crores new cases of occupational diseases are being added every year ! 40 to 50% of the total workers of the world apprehended physical, chemical, biological, ergonomic or mental hazards due to work. About 1 lakh chemicals pose serious health hazards. Some 300 pollutants can cause cancer. Skin, bones, lungs and kidney are the main target organs. 3000 allergens can cause skin diseases (dermatitis), asthma etc. Economic loss due to occupational diseases is @ 10 to 15% of the total world GNP. 75% of these diseases are preventable, adds the World Bank. In developed countries 20 to 25% and in developing countries, only 5 to 10 workers get occupational health services.

Central Labour Secretary Dr. L. Mishra told on the eve of 36ht Indian Labour Conference that factory occupiers do not provide safe and comfortable atmosphere to the workers and ignore their physical and mental well being. He added that 40 crore tones of chemicals are being manufactured in the world and more and more are being added to it. Out of one lakh chemicals used in industry and agro sectors, health hazards of only three thousand chemicals are known. 250 chemicals are carcinogenic. Contact with some metals, organic dusts and pesticides is dangerous, he added, and warned about the toxic dusts in paper and pulp industry, petroleum refinery and ceramic industry, insufficient lighting and ventilation, exhaust system and inadequate machine design. He was referring the agenda report prepared by the Central Labour Ministry for the above conference (News 13-04-2000).

Dangerous radioactive Cobalt – 60 was detected on wrist watches of brand name 'trafy' and made by Silk time Company of Hongkong. Atomic Energy Regulatory Board, Bombay and office of the Protection against Ionising Radiation, France issued warning against the use of this material (News 11-11-2000).

It is reported that high selling Gutkha contains Magnesium carbonate and it is banned for sale at certain public places. American Cancer Society has highlighted the increase incidence rate of cancer (adenocarcenoma) due to smoking of filtered cigarettes (News 7-11-97).

European Union announced prohibition on the products from animal organisms causing **mad cow disease** (News 7-11-97).

Germany has banned the import of Indian textiles containing **azo dyes** made from chemicals that it suspects are carcinogenic.

TV News are constantly warning about the continuously decreasing levels of water in land and simultaneously continuously increasing population and their massive demands. Coal, natural gas and petroleum are also constantly decreasing. Can it not pose a great danger to our lives after 50 years ?

Petroleum Minister Shri V.K. Ramamurty told in Rajyasabha that our Crude – oil stock would last for 27 years only (News 19-3-99).

Is it not shocking news that in Cherapunji – a place known for the highest rainfall – the water is being sold in buckets ? Failure of water planning will add to the health hazards.

The Chairman of the World Commission for Water has warned about the grave misuse of land and water sources. Polluted rivers spoil the eco systems and therefore the health and subsistence of people depending on irrigation, drinking water and industrial use of water have been seriously endangered (News 30-11-1999).

'In next two decades, 66^% population of the world may face difficulty of drinking water' said Kofi Aanan, the General Secretary of the UNO on the eve of 22-03-03 the World Water Day. He stressed on prevention of waste of water and told that the clean water is the most essential for human existence and continuous growth. (News 23-03-03).

Bhopal gas-tragedy of 2/3 December 1984, arose out of Methyl isocyanate leak, killed some 2500 people and left after-effects on thousands others. On 21-01-97 an Ammonia tanker leaked on Bhopal – Hoshangabad highway and caused some 400 people to be hospitalized and 30 acres land and crop badly affected. Reports of Ganga River pollution are also very bad. It has reported lethal effects due to Arsenic poisoning. Figures of pollution of Sabarmati river in Nov-Dec 1996 revealed that suspended solids were found 5134 to 56246 at four points against its permissible level of 100. In Delhi 70% air pollution is due to vehicles, which kill directly and indirectly some 7500 people every year ! (News, Editorial, 18-10-96).

Delhi, Calcutta and Bombay are included in the highest polluted 15 mega – cities of the world. Delhi is at No. 4 because of its highest level of suspended particulate matter (spm) in air. During 10 years from 1971 to 1981, industries increased from 20000 to 41000 in Delhi (News 4-3-97, the National Safety Day).

Reports of spoiling of the historical monument **Tajmahal** due to air pollution have also been published. Its whitening process was also started.

Fourth report of the Gujarat Legislative Assembly Committee speaks of the serious pollution problems due to the chemical industries in the state. Adverse effects have been noticed on agriculture, plantation, trees and the public health. The committee has urged the Government to take drastic steps to control this pollution. (News 9-3-97).

International Union for Conservation of Nature and Natural Resources, National Environmental engineering research Unit and National institute of Oceanography have warned about the dangers of gigantic oil refineries to Marine National Park (area 457 Km^2) and all living creature in a long sea coast of Saurasthra and massive pollution due to Carbon monoxide and Sulphur dioxide in that area. (News 16-03-97).

An alarming report has come from London that the **mortality rate** due to cancer is 20% high in children who born in the vicinity of pollution centers like oil refineries and cement factories. A study carried out in England, Scotland and Wales during 1953 to 1980 told that the mortality rate due to cancer in children below the age of 15 was much more higher who were born within 4 km. of the roadways and railways emitting vehicular pollution. It is also stated that the mortality rate was the highest in children who born within 5 km. of the plant using petroleum fuel (News 12-04-97).

Chrome ulcer is common with the use of Chromium and Bichromates. 30% workers were found with dermatitis and nasal septum perforation i.e. hole in noses (News. 10-07-98).

Greenhouse effect :

Another report from WHO has warned that the increasing proportion of CO_2 in environment will increase diseases like Malaria, Cholera, Dengue etc. and children may die due to such air pollution. Scientists are worried that proportion of CO_2 has been 30% increased during last two centuries. The increasing **greenhouse effect** increases earth temperature. It is well known that most of the factories and vehicles continuously emit tons of Carbon dioxide in the air. This greenhouse gas acts as a barrier in atmosphere and stops the reflected heat from the earth to go up. Therefore the temperature of the earth increase. Ozone depletion also adds to this. We are cutting the trees, which consume Carbon dioxide. The ultimate result in the continuous increase of CO_2 in atmosphere, which makes the earth a furnace ! It is only the wind (the God-gift) that dilutes and disperses this effect. They apprehend that 3 to 4 degree temperature rise will kill many birds and animals like tortoise. Warning is given that if China and India will not control their greenhouse gases in time, it will create serious problems. China has recently signed an International treaty to reduce her greenhouse gases. Signatures of 55 countries are necessary to implement this treaty. Water pollution in India has crossed its permissible limits. In industrial cities and surrounding villages, the water is not drinkable. Environmental erosion will frequently bring scarcity in India and Asia, it is seriously warned. (News 16-04-97).

PTI News from New Delhi published that in Bangalore city (known as Silicon Valley of India), quality of **'semen'** is being deteriorated due to air pollution. It is warned by the Reproductive Health & Research Centre of Bangalore that the quantity generation rate and deficiency of spermatozoa in male semen have been changed during last five years and the male fertility (reproductive health parameters) is decreas4ed due to polluted environment (News 2-06-97).

Scandinavian Research Report was also published on 21-05-94 to open our eyes. It covers studies in 20 western countries and states that during last decades, noticeable decreases in "Sperm Count' is reported. Comparing with a man of 1930, the present man produces only 50% sperm ! In England out of 20 couples, one couples has no potency to get child. This was due to the effect of pesticides on food.

Director of Science and Environment, Dr. Anil Agrawal, aid that the 'sperm count' of Indian males has been decreasing. A study report of males living in a polluted area in Mumbai, it was found that less than 30% of males were showing normal quality of their sperm. Excessive pollutants in that area were Lead, Sulphur dioxide and suspended particles in air. Chemical pollution causes cancer, heart troubles and hormones irregularities (News 12-07-98).

Overseas Development Administration (ODA) of England has warned that the air pollution has not only affected the human population, but it has reduced the productivity of some crops to 40%. Pollutant like SO_2 & NO_2 have adversely affected crop of wheat, rice, soyabean, groundnut, cotton and mango and it reduces healthful elements and tissues of leaves etc. Another report of WWF-India states and these pollutants make the crops more sensitive to pesticides and diseases. (News 9-6-97).

In USA the total SO_2, release is nearly 9 x 10^7 tons in a year. NO_x is believed to be involved in global warming. CO2 emission in air is some 5 billion tones per year. Earth temperature will be increased gradually. Carbon particles in soot, smoke etc. from combustion processes are undesirable. Fly ash generated from the combustion of pulverized fuel pose serious pollution problems.

A report of the Central Pollution Control Board says that the vehicles in India emit some 418 tonnes gases per day. These gases include CO, NO_x and hydrocarbons, and constantly affect our health (News 9-6-97). Today some 2.7 million vehicles emit CO_2 in air (News 14-9-97)

Five young boys of 14 to 18 years, died at a time when they were sleeping in their house after forgetting to stop a portable power generator, which was used to see TV in absence of power supply. It is reported that doors and windows of the room were closed. What could be the causes of their death during midnight ? Certainly the toxic gas generated from the fuel exhaust and containing CO, NOx, other hydrocarbons and oxygen deficiency (News 6-8-97).

In a seminar organized by the Institute of Engineers (India) at Ahmedabad on the subject of 'Urban Landscape and Gardening', it was highlighted by the environmental engineers that in Ahmedabad City only the motor vehicles emit daily some 240 tonnes Carbon monoxide, 30 tonnes Hydrocarbons and 9 tonnes Nitrogen oxides. It was pointed out that the main air – pollutant in our country is Sulphur dioxide, which is mostly generated by industries. It was suggested for fighting these hazards and keeping the environment clean, to plant and nourish as many trees as possible. It was said that tree plantation in 500m2 area reduces 70% pollution. One Peepal tree (which we consider holy) throws 1700 kg Oxygen in air in one hour and eats 2300 kg Carbon dioxide as its food ! The natural pollution control device !! (News 22-8-97).

People have cut so many trees that it is apprehended that in the 21st century we shall have to face the Acid rain.

One higher official of the Central Environment and Forest department and a member of the Central Crisis Group visited the HPCL refinery to investigate heavy fire incident of 14-9-97, told newsmen that there are 1254 major accident hazard factories in India, of which 300 are in Gujarat. The department has prepared state-wise lists and identified other 12702 hazardous industries also. Near Delhi there are 23, in Mharashtra 278 and in Bihar there are 82 major hazard installations that can cause great damage. The units storing petrol, LPG, ammonia, chlorine, nitrates, etc. in bulk quantity, can be proved the most disastrous. 34 plants of HPCL can causer emergency at any time. Such units are told to submit safety reports and emergency action plans (news 29-9-97).

The Gujarat High Court ordered to reduce 50% production of 72 polluting factories at Vapi (News 30-10-97). The Supreme Court ordered to close as many as 168 industries in Delhi. About 25000 workers became jobless and no salaries and compensation were paid to them. Five major trade unions made demonstration saying "SC rulings have put us on starvation. Article 21 of 'Right to People' was interpreted in favour of public but no in favour of workers. (News 10-01-98. it is the health hazard of pollution only that invites such cry, closure or reduction in production and employment. This sequence may continue till adequate safety measures result in prevention of pollution.

In the State level meeting of GPCB at Gandhinagar, it was reported that some 9000 chemical units out of total 20000 units in the State, pose great danger to human health due to air and water pollution. 3267 closed units due to High Court's order were allowed to restart after constructing the effluent treatment plant (News 15-10-99).

CAG Report (Comptroller and Auditor General) as on 31-03-2001 of Govt. of Gujarat published an audit report. A few salient points are as under.

1. Rs. 3.38 crores given to GPCB to adopt clean technology during 1994-99 was not all utilized !

2. There was no coordination of GPCB with other Department to stop water pollution.

3. No sample from any Sewage Treatment Plants of five Municipal Corporations was meeting the standard.

4. Two major sewage treatment plants of Ahmedabad Municipal Corporation were illegallary discharging effluent without treatment !

5. 83 out of 110 local Panchayats have no gutter system.

6. Observations regarding common effluent treatment plant (CEPT) in industrial areas were also not good. Expected treatments were not given by the member industries before sending effluent to the CEPT. Discharge of CEPT was also not meeting the standards. One CETP at Vapi was directly discharging the effluent (without treatment) into Damaganga River ! Many fishes were died due to this. Only a notice was issued by GPCB in this regard.

7. Villages containing high fluorides in water were increased from 803 to 1304 from the year 1997-98 to 1999-2000. Villages containing TDS (Total Dissolved Solids) in water were also increased from 567 to 960 during this period. More than 100 villages were having excess nitrate in water.

Such report are available for many departments and for many years ! Who makes use of it and who tries to improve the condition is a big question. Is it not a problem of Safety ? Intention of citing such alarming reports is to awake and implement the concept of safety.

Because of gases coming from Vapi GIDC estate, the monsoon rice crop at Karvad village was greatly damaged. Because of water pollution is Sabarmati River, thousands of fishes were found dead (News 26-8-98).

The problem of solid waste disposal is also not solved. Throwing it in river or sea can kill fishes and other living creatures. The National Plastic Waste Management Working Group has recommended prohibition on recycling of dirty plastic waste as it contains impurities (News 12-10-97).

Dangers of Pesticides :

After dumping an average of 50000 tonnes of pesticides annually in the past 30 years to improve our agricultural yields, the land is so poisoned with BHC and DDT that, even if spraying were stopped, the chemicals will linger on for 50 years more ! The studies have shown that high percentages of these pesticides are being found in cow's milk. Now we will have to turn towards eco-friendly bio-pesticides not injurious to land.

Ahmedabad Consumers Education & Research Centre collected (in the year 2000) from different parts of the country 13 samples of flour being sold by big-named companies. All the samples found containing DDT ! Agricultural use of DDT as pesticide is banned for more than 12 years. Even then DDT, Aldrin and Dieldrin have been repeatedly found in the samples f flour, eggs, milk, butter, ghee, pulses, fish and vegetable oils. Contaminated food by such pesticides, after entering the human body, increases possibility of many diseases.

Samples of mothers' milk have shown the DDT content six times more than the maximum residual limit (MRL). Such a heavy overdose stops the child growth. A study conducted by Indian Council for Agricultural research showed traces of DDT and Aldrin in 57% of vegetables. Even strain (grass) for report of 'Toxic Link', about 147 types of pesticides are manufactured in India of which Government has prescribed MRL for 50 pesticides only. We do not know MRL of other 100 pesticides !

International Development Research Centre of Canada says that about 10,000 people die every year and about 4 lakh people suffer adverse health effects, due to pesticides poisoning.

Study reports state that effects of pesticides and preservatives for our food, fruits, milk and vegetables are dangerous to our health.

In China only in 1995, in 27 States, 48377 cases of pesticide poisoning were reported, of which 3204 were fatal ! 7500 cases were due to Parathion and Mithamedophos. Food and Agriculture Organization (FAO) and United Nations Environment Programme (UNEP) declared additional five Organophosphates (Mithamedophos, Methyl parathion, Monochrotophos, Parathion and Phosphamedon) the most poisonous, and imposed ban to export them without the consent of an importing country. Total there are, so far 29 such chemicals having lethal effects. The world market of pesticides was of Rupees thirty thousand million dollars in 1996 and is rapidly growing (News 25-9-97). Is it not a struggle of wealth (so many million dollars) verses health (more than the mere cost of so many lives) ?

A young daughter (Age 15) and her mother both died when they took Aluminum phosphide tablets for suicide. This pesticide tablet when mixed with body-fluid generates phosphine (PH3) gas, which kills a person (News 28-10-99).

At a time 7 peacocks and many other birds died in Rundel village near Borsad, on 3-12-97, due to pesticide poisoning in a farm. (News 4-12-97).

Scientists of National Institute of Nutrition, Hyderabad warned about Aluminum poisoning and effect on CNS and brain due to excessive use of acidic food prepared in aluminium vessels (News 6-9-98).

5000 doves trapped in paralysis and showed symptoms of pocks, tumour and cancer in Mumbai due to contaminated jawar given to them (News 23-1-98).

'In India where 80% people depend on agriculture, more than 20% males may lose their potency to become fathers in a coming decade', says a young research biologist Shri Nimish B Vyas at

Ahmedabad while talking on effect of excess toxicity in pesticides and insecticides. 'In America and Europe voluntary organizations are warning people about this' he ads. In India also such awareness is timely required. (News 23-6-98).

Adulteration:

Adulteration of oil of Orgamon Mexican (an American Plant) in edible oils hospitalized thousands of people and caused disease known as Dropsy. It attacks liver, kidney, heart and ratina (News 11-09-98).

Mixing of Palmolive in groundnut oil is very common.

More than 20000 adulterated food products have been reported and many more are being added daily. Some 30 years before one science magazine Lancet had warned that every person in Great Britain was adding an average 3 lbs poison in his stomach. Because of more adulteration in our country, this figure could be 30 lbs nowadays. A list of some adulterated substances in given in Table 1.2.

Table 1.2 : Adulteration of Substances.

Substance	Adulteration	Health Effect
Rape seed oil	Orgamon Mexican	Heart & eye
Edible oil	White oil	Cancer
Turmeric	Lead chromate	Paralysis
Wine	Methanol	Blindness
Apple & other fruits	Lead arsenate, Lead chromate	Paralysis, Blindness, anaemia
Tinned food	Cadmium	Food poisoning
Meats & vegetables	Celurojela	-do-
Fish	Formaldehyde	-do-
Tea, Water & toothpaste	Fluorides, Bone powder	Teeth & bones
Bread	Fuserium preminehum rozium	Food poisoning
Polished rice & puses	Asbestos	Cancer
Ice-cream & Sweets	Sodium carboxyl methyl cellulose, Metanyls yellow, Rhodamene B, Orange 2.	Cancer
Capsicum, Confectionary & Ice-cream	Polish, Nonedible colours	Injury to stomach
Flour	Sand & dust	
Tea	Colour & iron powder	
Milk & Milk products	Starch	
Pure Ghee	Vegetable Ghee	
Chinese Food	Monosodium glemate	
Chocolates	Vanillin & Propylene glycol	
Jaggery, Mushroom	Zinc sulphide, Bleaching powder.	

In bulk capsicum powder exported by Bombay Merchants, a carcinogenic substance 'Sudan red-1' was mixed. Spices Board of India prohibited such export.

As per one report of Indian Council of Agricultural Research, 60% food grains contain pesticides. In most of the samples, level o pesticides was found 14 times more than the maximum tolerance limit (MTL).

Thus the adverse health eff4ects due to food adulteration are very serious (News 11-9-98).

Because of adulteration in seeds for sowing, farmers suffer loss every year. The crop becomes poisoned because of pesticides and pollution. A mixture of earth and cadmium is sold as Phosphatic fertilizer, blue ink as pesticide and chalk as DDT. Methyl parathion is sprayed on cauliflower to make it whiter and green vegetables (e.g. lady's finger) are dipped in copper sulphate to make them greener. Samples of mothers' milk have shown excess DDT (17.18 ppm) and DDF (26.66 ppm). This can be a cause of mother's cancer. Poisonous chemicals in dead fishes were found 2000 times more than their safe limits ! Milk sold in Uttar Pradesh was found synthetic i.e. made of caustic soda, urea and soda solution ! American Soyabean is made by a technique of genetic engineering. 44 types of diseased bacteria were found in 10 lakh tonnes wheat imported from Australia. A vital cause of disease like cancer, heart attack, blood pressure, blindness, infertility etc. is such criminal adulteration (News 16-10-98).

12 types of food grains and other atables being sold in Gujarat were tested in laboratory and the results are as under :

72% of dairy product samples were found poisonous, 50 to 60% samples of grains and pulses, 23% samples of wheat flour and 90 to 100% samples of vegetables were found containing DDT and BHC. The contents found are given in Table 1.3 :

Table 1: 3 : DDT & BHC in Food grains

Sample of	DDT (PPM) (Safe limit 0.5 to 5.0 ppm)	BHC (ppm) (Safe limit 0.01 to 2.0 ppm)
Wheat	5.15	18.07
Tuver Dal	7.75	5.86
Rice	7.80	24.82
Ground Nut	7.24	4.12
Butter	6.15	4.62
Cheese	1.03	0.88
Ghee	2.03	1.34

DDT destructs body resistance and CNS and increases cancer possibility. BHC damages liver, kidney, embryo, generative organs, body resistance and also responsible for cancer. Use of these two pesticides needs complete prohibition (News 27-6-2001).

A report of a committee constituted by the Delhi Court says, 'Oxytocin, a hormone being given to cows and she-buffaloes to get more milk, is a slow poison and brings kidney and liver trouble' (News 13.09.99).

'Green fodder – Juwar, Makai, Bajari, Rajko etc. – contains poison', the Animal Husbandry Directorate of Gujarat State warned it and precautionary measures were suggested for the farmers. Unripe, soft juwar emits Hydrocyanic acid, urea fertilizer generates Nitrate, green Rajko gives 'Seyoniue', Subabul leaves produce 'mymocine' and all pesticides in green grass, fodder or vegetables can generate 'poisons' and kill animals when they eat it. Therefore it is not advisable to give green soft fodder, leaves, vegetables etc. to animals and to give immediate water after such food' (News 11-12-2000).

During summer when demand for ice-cream kulfi and cold-drink increases, it was found that white poster colour and safedo (white powder) were added in the manufacture of ice-cream, kulfi and cream-candy and saccharine was added in cold-drinks and in ince-candy. After detecting such adulteration, Health Officers of Lucknow said that poster colour and safedo add lead in the body and its delayed effect is damage to brain and its control activities and the delayed effect of saccharine is a cancer (News 2-6-99).

Adulteration of urea in milk to maintain fat level, mixing of talc / chalk (Magnesium silicate) in flour and spices, orgamon in mustard oil, starch in sweet, old (renseed) oil in new oil, mineral oil in edible oil, vegetable oil or boiled potato in ghee or butter, molasses (sugar waste) in honey, chalk in salt and sugar are some published reports.

Cadmium used in cigarettes, some antiseptic medicine, colours, chemicals etc. cause hypertension. Aluminum used in antacid drug to cure acidity causes mental effects. Lead and mercury are other metals, which damage brain and kidney.

It is very surprising that one of the reasons of fall of Roman Empire is said to be lead poisoning ! Romans were filtering wine in lead lined vessels and because of drinking of such 'leaded wine' they had mental effects, which resulted into their defeat.

'Health of 70% of our agricultural labour is not good' says the India Council of Medical Research. Its survey states that this health effect is due to pesticides, tobacco dust and genetic diseases like leptosprirasis due to contact with animals (News 4-11-97).

Water Pollution:

The water that we drink everyday is 70% polluted ! Out of 3119 Cities of the country, only 219 have water filtration plants ! And that too covers only 33% of the city population. This massive water pollution is a very serious matter. In India, about two third diseases like, typhoid, cholera, jaundice and diarrhea spread due to water. Many such diseases have full potential to be epidemic (News 12-10-97).

Water Supply Board of Gujarat has published some figures of adverse health effects. These are given in Table 1.4 :

Table 1.4 : Adverse Health Effect of Polluted Water.

Year	No. of People adversely affected by drinking of polluted water
1997	32000
2000	46000
2001	50000

(News 27-5-2002)

New York Times published a report that lakhs of people in India and Bangladesh drink water mixed with Potassium cyanide from water wells. Only in West Bengal 60 lakhs people drink such water, out of which some 3 lakhs have shown symptoms of cyanide poisoning on their bodies. Potassium cyanide can cause cancer. Shri K.J. Nath of All India Institute of Hygiene & Public Health has also warned about this problem (News 12-11-98).

Chennai Health Laboratory tested 191 mineral water bottle samples and found bacteria in samples ! In samples of soft cold drinks also, bacteria and excessive saccharine were found. Ordinary tap water is sold in brand named bottles at the price of Rs. 14 (a price of 1 ltr milk) per bottle ! This may cause typhoid chemicals (BOD & COD) are not safe (News 4-6-98)

16 rivers and 18 lakes in Gujarat have been polluted. The Central Pollution Control Board has identified the most polluted 20 rivers in the country. Proportions of pH, dissolved oxygen and dissolved chemicals (BOD & COD) are not safe (News 4-6-98).

Dr. MGK Menan Committee Constituted by the Govt. of India under the directive of the Supreme Court has added one more warning. It has published that 70% water resources of so-called Golden Corridor (Industrial belt between Vatva to Vapi of Gujarat) have been polluted, people have contracted diseases due to pollution and a great scarcity is caused of drinking water and water for irrigation. It has also reported hat at 40 places in Gujarat, hazardous waste is dumped illegally and no action is taken by GPCB (News 4-4-2001).

A report of pollution effects due to chemical factories from Atul to Vapi is published in a Newspaper of 18-10-98. It states that production of Hafus mangoes has been decreased ten times in village Haria and water in well have become coloured. When water is filled in a glass, a thin layer of deposits is visible on inner surface of the glass. Red water is thrown in Khadi (ditch) by three pipelines of one-foot diameter, even animals do not drink this water and whenever they drink they die. In winter very bad smell comes from nearby factories. Fishes die in sea and railway bridges are rusted. Fishermen are in great trouble as they do not get fished nearby and have to go far in deep sea. Because of chemicals in water, hairs on their legs are removed and they feel burning. As per the statement of Kolka villagers some 40 to 50 people have been died because of cancer during last 5 to 7 years. Poison through fishes also affects.

Billkhadi near Vapi is full of dirty water. Solid and thick oily waste is thrown here and there on the bank. Thick yellow liquid is drained in Damanganga River. Crop in many villages is destroyed. Because of fog in polluted air, it becomes difficult to see even at a 50 feet distance. Because of the worst pollution of water, the surrounding villages have been declared as no source villages. Coloured water comes from hand pumps. Solid waste is brought and thrown near houses during night hours. Some scattered public agitations were going on but ineffective.

Another report of water pollution is also published on 29-12-2000. it states that water in 22 talukas of Gujarat has become heavy because of Sodium, Iron and Calcium ions. Less Dissolved Oxygen (DO) and high COD, Cadmium, TDS, Mercury, Fluoride, Manganese, Chromium and heavy metals have been found in water in these talukas. About 10% area of the State has been polluted and has created threats to the **public health**. The Golden Corridor has become the Black Iron Corridor.

Alang shipyard has heavily polluted the coast of Bhavnagar district in Gujarat. During last two decades, thousand of tons of oil and chemicals have been thrown into the sea while breaking the ships. One drop of oil kills all aquatic lives from 25 liters of water. Marine tortoise, mangroves and aquatic animals are being died day by day due to this coastal pollution (News 4-1-2007).

Out of 19111 villages of Gujarat State, inland water of 1408 villages has become salty and therefore not drinkable. 2826 villages have fluoride mixed water. Such salts dissolved in drinking water cause damage to kidney, bones, teeth and blood constitution. Salty water becomes heavy and not useful for washing clothes and for agricultural purpose (News 5-7-2001).

Air Pollution :

"Throughout the day the chimney spews coal dust. We can feel it in the air" said a rickshaw driver and the worst affected people living within a kilometer of one Rayon factory at Veraval, Saurashtra. A BMS union leader also complained of continuous air pollution. The company authorities deny and put forward the industrial safety and pollution control awards won by the factory ! Residents of 30 housing colonies on the 80 feet road are badly affected (News 4-10-97). The similar problem of coal dust in surrounding area was also continued in the vicinity of a textile mill at Navsari. Our intention is not to criticise anybody but to highlight the struggle of health v/s wealth and to draw attention to protect the health.

A survey carried out by the Central Pollution Control Board has reported some figures of air pollution in tons/ day in five major cities; Delhi 1046.30, Mumbai 659.57, Bangalore 304.47, Calcutta 293.70 and Ahmedabad 292.73. Police personnel working on roads have 10 to 25% more diseases of lungs. Lead fumes from vehicle – exhausts directly enter into lungs and cause TB, asthma and other lung-diseases. Unleaded petrol is recommended but benzene content in it can cause cancer and skin disease ! To reduce its effects catalytic converter is suggested.

Despite of enforcement of all pollution control rules, the developed countries emit every year 150 lakhs ton Carbon monoxide, 10 lakhs ton Nitrogen oxide, 15 lakhs ton Hydrocarbons and millions of tons of Carbon Dioxide in air. Some 70% of air pollution in the world is in the developed countries. Some 80% of the cancer – patients in the world are due to the polluted atmosphere ! (News 5-11-97).

In China, 3 lakhs people died during 1994 to 1996 and in India, 52000 people died in 1998-99 due to air pollution. In blood samples of 100% children in Shanghai and 64% children in Delhi, Lead content was found excessive. During 1950 to 1999, 200 thousand million tonnes Carbon has been added on the earth. During last century the global temperature is increased 14.57^{o}F (News 9-9-99).

Because of the financial loss due to injuries, deaths and degradation of resources caused by pollution, India loses every year some 80000 million dollars, says the World Bank. Because of increasing industrial and urban pollution, excessive land use in villages, destruction of forests and tremendous use of water resources, this situation increases. In South Asia main environmental problems are deteriorating quality and scarcity of water, air pollution and poor water management (News 9-10-98).

Gold and Silver refinery furnaces in Ahmedabad were reported causing heavy air pollution. Welding metal Cadmium causes kidney damage and high blood pressure. NIOH is given a job to conduct survey for health effects (News 29-10-98).

The dangerous health effect of air pollution is again reported. American Lung Association reports 5000 deaths every year due to asthma. During last 15 years, 61% increases is noticed in asthma-patients. Out of 150 lakhs asthma-patients in USA, 50 lakhs are children. They have to carry an inhaler pump daily in their schoolbag to use it by mouth when asthma attacks. American Lung Association published a ‘Family Guide to Asthma and Allergies’ and highlighted this increasing disease of the modern world. IN near future the asthma may overtake the spread of cancer and AIDS if the dust and air pollution are not controlled. (News article 5-11-97).

The Social Infrastructure Development Board of Gujarat has published that the GPCB has been failed to control the industrial pollution, most of the cities in the State ore covered by the excessive emission of SO_2 and its 100 to 500 µg detected level (against 60 µg permissible level) makes the cities ‘gas chambers’ and invites many diseases of eyes, throat, skin, fingers, hearth, breathing, blood circulation and cancer (News 6-1-2001).

Daily we inhale some 14 kg air, which contains some 6 kg toxic gases like CO2, SO2, Ammonia, Lead, hydrocarbons etc. In Gujarat complaints of allergic cough have been increased 20 to 25%. Health effect of polluted air is equivalent to smoking of average 20 cigarettes per day. One of the reasons of decreasing sleep in industrial cities is also the polluted air. In Delhi a trader has started a business of providing clean air at the rate of Rs. 180 per hour ! (News 17-3-99).

23 cities of India are exceeding air pollution levels and every year some 40000 people die due to environmental pollution. Every year Rs. 4550 crores are wasted in medical treatment of pollution sickness. Thus says the WHO report. Suspended particulate matters (spm) are 3 times more than the WHO limit. Vehicular air pollution in Delhi, Calcutta and Mumbai are 65%, 52% and 30% respectively. Vehicles emit NO_x, SO_2, hydrocarbons, lead etc. Due to inhalation of these poisonous gases people die earlier. Diesel exhaust is most dangerous. It harms 10 times more than the leaded petrol. It can cause

direct blood cancer. Unleaded petrol in India contains benzene, which can cause lung and blood cancer. Lead in petrol causes brain damage in children. Therefore use of leaded petrol is prohibited in America, Japan, Canda, Austria, Sweden, Brazil, Columbia and South Korea. Process of removing lead from petrol is cheap. Still 90% vehicles in India run by leaded petrol. In Gujarat, solvent and kerosene are mixed with petrol. Are these petrol pumps not the killing centres ? (News 18-12-97).

Because of many complaints of kerosene mixing in auto-rickshaw, the ADC and also DSO raided at night and found sale of kerosene to rickshaw- drivers in Surat. Some 4400 litres of free sale kerosene was seized. At four petrol pumps, samples of petrol and diesel were found adulterated. Such is the condition of vehicular pollution in many cities in our country (News 23-11-98).

During 1980 to 1990, loss due to pollution was Rs. 131298 crores, as calculated by the National Environmental Engineering Research Institute, Nagpur. Losses due to cutting of forests and air and water pollutions are day-to-day increasing (News 21-05-98).

Dr. Rashmi Mayur, an advisor of United Nations Environment Programme warned at Ahmedabad on 5-6-98 (World Environment Day) about the damage being done to the forests and forest products; wildlife; rivers; seas, land and all natural products.

He told that 50% land and 70% water in Gujarat have been polluted. Most of the land in Kheda District has become salty. Ahmedabad has been declared the most polluted city by the Sulphur dioxide. About 2500 Km^2 forest area was lost just in last one year in India ! If environmental balance will not be maintained, skin cancer may increase at the annual rate of 5%. Instead of depending on the Government, people should make the movement. Manpower and awareness should be created (News 6-6-98).

During last 10 years, vehicles have been 3 times increased in India. In 1986, there were 1.1 crore vehicles registered. This figure rose to 3 crore in 1995. Out of this, 35% vehicles are in 23 mega cities. Maharashtra and Gujarat are at the top with 36 lakhs and 30.2 lakhs vehicles. Planning and Programme Implementing Ministry has warned that the tremendously increasing use of vehicles is polluting the environment by toxic gases like CO, CO_2, SO_2, and hydrocarbons (News 31-1-98).

As per report there was an addition of @ 6 lakhs vehicles during 1990 to 1999 in Ahmedabad city only reaching a toll of @ total 11 lakhs registered vehicles in the city. Out of @ 50000 auto-rickshaws, 70% auto-rickshaws add 3 to 4 litre kerosene daily. PUC machines for checking fuels do not check Benzene, Sulphur and Lead contents, which are the main pollutants ! These three contents must be decreased from petrol and diesel (News 28-11-1999).

Coal bed methane (CBM) can be used as a new fuel in the next century to reduce vehicular pollution. It is successfully used as a commercial fuel in USA, Germany, France, Poland and Czech Republic (News 4-12-1999).

Two persons died in a bathroom at Ahmedabad due to the use of gas-geyser. Oxygen deficiency due to LPG burning and CO generation by incomplete combustion due to less availability of oxygen in a confined room can be proved fatal in this way. Other 3 persons were also died in the similar situation during last one year (News 19-12-1999).

Tobacca Poisoning :

WHO Report says 3.83 lakhs people died in India and 9.13 lakhs people died in China during 1998 due to tobacco eating and smoking. By the year 2030, some 1 crore people in the world would die due to the use of tobacco ! Female proportion is day-by-day increasing in this regard (News 31-5-99).

Another report of WHO says that by the year 2030, death toll due to tobacco may reach up to 10 lakhs per year in the world.

India produces 4.40 crore kg tobaccos every year, of which 80% is consumed in the country. In other words, about 3 crores people smoke/ chew tobacco in one or the other form in our country. In India about 1.90 lakhs tobacco cancer patients are added every year ! Rate of heart attack is also more in tobacco users. Indirect smoking is also dangerous. Many poisonous gases are evolved while smoking of tobacco. Exposure to tobacco smoke causes asthma and lung cancer. 31st May is celebrated as Tobacco Opposition Day in the world. Awareness against tobacco poisoning is most necessary. (News 31-5-2001).

A Washington Report warns about another danger of tobacco smoking. A study report of 60 smokers is published by American Scientist. It reveals that if a person having high blood pressure smokes, chances of his being impotent increase 27 times ! Not only that, but possibility of being impotent is 11 times more in those who have left smoking comparing them with those who do not smoke.

One crore Americans and one lakh British of age group of 30 to 40 have become impotent due to the adverse health effect of tobacco smoking. (News 31-05-2001).

Radiation and Other Hazards :

An Environmental Assessment Division of **Bhabha Atomic Research Centre**, Mumbai conducted study of 81 employees who died due to cancer and who served from 1971 to 1992 with their age-range of 20 to 59 years. Dr. K.S.V. Nambi and Y.S. Maria in 'Indian Journal of Cancer' published this study report with the conclusion that an incidence of cancer was certainly higher in employees working in **atomic radiation** zone than those working in non-radiation zone. The effect of radiation was responsible for higher incidence rate of cancer. (News 25-12-97).

Fifty percent of the X-ray machines of our country are unsafe and may cause cancer. Higher doses of X-rays can cause death or cancer as a delayed effect. Thus said the Atomic Energy Regulatory Board and the Council of Scientific & Industrial Research based on their survey started in 1994 (News 17-12-99).

Warnings have been issued to continue very old atomic power stations. Out of some 400 atomic power stations in the world, 170 are 25 years old and 60 are 30 years old. Radioactive wastes thrown by Tokyo Electric Corporation killed lakhs of aquatic lives in the sea. Message of Chernabil accident in 1986 in Russia is eye opening. Stringent safety rules, safe disposal of atomic wastes and emergency planning must be strictly followed.

Mr. V.R. Singh, the Head of Instrumentation and Biomedical Ultrasonic Department, National Physical Laboratory, New Delhi, warned about the Hazards of Ultrasound Devices being used in hospitals and nursing homes. He told that such machines would injure the health of both, the operator and the patients. Sound waves above the permissible frequency cause damage (News 26-02-98).

Forest are being cut heavily and at the fastest rate. Some 6 billion hectares forests and jungles have been reduced to 3.2 billion in the last century. This is the removal of environmental protection and invitation to new hazards. But the greatest hazard of hazards is the P**opulation Explosion** ! Every minute 54 babies are added in India (like addition of Australia population at every eight months). No facilities will be sufficient to serve this ever-increasing population. This will certainly create many problems of health and safety also (News 19-4-98). India will become the highest populous country in the world by 2050 (News 23-03-99).

A report of a scientists' committee of European countries has warned about toxic effects of plastic toys for children. Most of the toys are made from plastic waste or poor quality colours and chemicals.

Chemicals used to make toys soft and attractive to put into mouth are dangerous. In USA, Foods and Drugs Department has made rules for safe manufacture of plastic toys (News 5-10-98).

A common solid waste – polythene bags – has caused fear on animal lives. Cows and other animals eat these plastic bags (waste) thrown here and there. They also cause problems when choked in pipelines. Therefore the Rotary Club of Gandhidham raised a move to motivate people to use paper bags instead of polythene bags (News 28-10-98). Use of thin plastic bags (<20 microns) has been prohibited under Recycled Plastic Manufacture and Usage Rules 1999.

'**Lead poisoning** is increasing in the blood of our children' alarming news came from a survey carried out of some 22000 samples by the George Foundation. Children below 12 years are badly affected in our major cities because of the petrol pollution from thousands of vehicles. In 34% children lead level in blood has crossed the international level. It reduces the child IQ by 6%. Environmental protection is highly needed for Indian Children (News 16-03-99).

A study report of NIOH (National Institute of Occupational Health), Ahmedabad was reaffirmed this fact and stated that due to high lead content in blood, children's IQ can be decreased and due to adverse effects on pregnant women, intelligence of future babies would also decrease (News 11-1-2000).

Hazard of Modern Living :

Sick building syndrome due to internal pollution generated by noise from water on air cooler, air-conditioner, generator, printer etc. in homes or offices causes breathing trouble, deafness, sleeplessness, tiredness, headache, eye burning etc. Chemical rays from paint, varnish, nail polish, boot polish, mosquito liquid / gas pesticide and Carbon monoxide from fuel burning cause lung diseases. Long working on computer causes breathing trouble, deafness, sleeplessness, tiredness, headache, eye burning etc. Chemical rays from paint, varnish, nail polish, boot polish, mosquito liquid / gas pesticide and Carbon monoxide from fuel burning cause lung diseases. Long working on computer causes eyestrain, which needs antiglare screen. Rooms having gas-stove, kerosene stove, furnace, electric heater must have exhaust fan or sufficient windows otherwise fuel gas causes cough etc. Air fresher, deodorant, hairspray, varnish, polish, wood-binder (resin) etc. spread irritant gases in air.

Use of cosmetics is day by day increasing with an increase of beauty – parlours and otherwise. Chemical cosmetics contain many harmful substances like silicon jell begs to increase breast, hydrocarbons, solvents, para-phenylenediamine (hair-dye), ammonium perceulate or thioglucose etc. No toxicity or standard (e.g. IS) is mentioned o such products. Therefore use of such chemical soap, cream, powder, foundation, nail polish, lipstick, bleach, wax, hair-dye, hairspray, hair-remover, aftershave lotion and cream, perfume spray etc. should be avoided or minimized. Their health effects are adverse. Non-chemical, herbal or Ayurvedic cosmetics may be used. Before their use, body test is necessary.

Warning to drop use of cosmetics must be heard by the women of the world. National Institute of Occupational Safety and Health of London said that 900 chemicals used in cosmetics are toxic. Botox i.e. Botulinum toxin is highly toxic. If 1 gram is sprayed in the air, it can kill many people. Benzene, Formaldehyde, toluene, collagen, acuten and laser rays can cause cancer also. They disturb body hormones; remove sex desire and damage lungs and mucus membrane (News 27-11-02).

Simple one hour walking and deep breathing or Yogasana can preserve health and beauty.

Most of the cosmetics contain toxic and flammable substances like benzene, formaldehyde, coal tar, lanolin (wool grease), phenylenediamine, phenoxyethanol, paralence etc. which may look non-hazardous in test tubes but they become hazardous when entered in skin or become old.

They are used in eye shadows, shampoo, skin-cream, blushers, lipsticks, mascara, hair spray, perfumes, moisturizer, toothpaste, soap etc.

Nail polish contains very hazardous chemicals like Acetone, Sprit, Methyl benzene. Phenol, Formaldehyde. These chemicals destruct natural shining of the nails and if ingested through fingers and mouth, they damage stomach and liver and may cause cancer if taken excessively or repeatedly.

Individual level of such chemical may be less than the 'permissible limit' as claimed by the manufacturers but their synergistic or total effect due to prolonged use can cause allergic reactions and serious damage to body hormones and make us ugly or sick or weak after some time. Daily use of lipstick amounts to @ 60 kg during lifetime'

Not only eye or skin sensation but they also cause cancer, disruption, neurological damage, miscarriage and harm to child in mother's womb.

Book like 'Protect yourself from the Hidden Dangers of Cosmetics' and many warnings are published for our safety. Do we want to awake and forgo such mad use of the cosmetics or not? (News 285-03)

Consumer Guidance Society of India, Mumbai has warned the women regarding their *Sindur* and **Bindiya** that they are now poisonous! **Sindur** contains Lead oxide and kumkum Mercury sulphide! Sticker type bindiyas (forehead points) can also impair the skin. Indian Standards should be prescribed for non-toxic chemicals to be used in such cosmetics (News 18-4-98).

Exceeding use of hair-dye also increases lead level in blood; it is so reported by Dr. T. Venkatesh, the Chairman of St.- John National Academy of Bangalore. It reduces memory, adversely affects CNS and brings unconsciousness sometimes (News 17-399).

Flavours and Fragrance has also been poisoned by chemicals! Artificial flavours and fragrance of strawberry, raspberry, mango, apple, guava, banana, sandalwood, soaps, shampoos and even of milk are manufactured from various chemicals like Amy I acetate, Amyl butyrate, Amyl valorate, Ethanol, Anicyl formate. Benzyl acetate. Benzyl isobutyrate. Butyric acid etc. Some artificial tastes are generated as under:

Taste of	**Generated by**
Popcorn	Methyl-2-dylecton
Apple Milkshake	Ethyl-2-methyl-butirate
Almond	Benzaldehyde

Milkshake contains alcohol. French-fries (potato wafers) are fried in cow tallow and freeze by compressed Ammonia gas. Six months stale items are also sold after refrying.

Health effect of such junk food or fast. food is to spoil our stomach, CNS, liver and kidney. They cause acidity, hypertension and food poisoning. They increase fat and weight, which in turn invite other diseases. 'World Watch Institute' says that some '12 crores people of the world are 'overweight' due to eating of such fast food and French-fries. It is also reported that some 2 lakhs Americans get food poisoning everyday and some 14 people die daily due to food poisoning (News 18-6-03).

The use of ultramodern equipment has also posed danger. High frequency electromagnetic waves from kitchen micro-oven, cellular phone, pager, hair drier, washing machine, electric blanket, room heater, personal computer, TV, video display terminal etc. can cause serious health hazards like leukaemia (blood cancer), brain damage, liver damage, bone marrow injury, miscarriage and adverse effect on body cells and DNA (News 8-12-97).

Similar warning was again issued at the **International Seminar** at New Delhi. 'Excessive use of such electronic equipment (mobile phone, pager. Fax m/c,, micro ovens, hair direr, TV, toys etc.) may cause cancer, skin disease, brain or heart trouble etc. due to electro magnetic field' it was so declared (News 23-12000).

Report published in 'Epidermilogy' journal, by Dr. Andris Stener of Emin University of Germany, states that incidence of eye cancer was found much more in mobile phone users when a group of 118 such users was compared with a controlled group of 475 people not having cancer. Fluid in eye cavity detects phone wave radiation very fast (News 17-1-2001).

As per Dutch report, headache and nausea due to mobile signals from base stations (third generation network) have been reported from public living in vicinity. (News 02-10-2003)

Dry cleaning chemicals (e.g. Perchloro-ethylene) increase 25% more chances of cancer and adversely affect tongue, lungs, neck and blood pressure; it is so reported by the National Centre of Occupational Health and Safety at Cincinnati, USA. (News 3-4-2001)

Dry-cleaned cloths emit Trichloroethylene, which causes nausea, headache and giddiness. Therefore they should be kept in open air for some time.

Warnings about increasing use of **non-stick utensils** are also published. Teflon or M-8C coated utensils are used in kitchen to fry or roast *dhosa, pudla, thepla* etc., as they need less oil, the food does not stick to the vessel and therefore less labour to clean them. Reports have been published that this coated chemical (black or brown) is very toxic and its poisonous effect is found in the blood samples of 90% of the users! It adversely affects unborn child, newly born child and others.

Glaze (lustre) of **ceramic vessels** (e.g. cup-saucer) contains lead: Food and Drug Administration of USA has warned people to know this lead level before using such vessels. It is advised not to store hot and sour eatables for long time in .it otherwise excess lead decreases haemoglobin in the blood (News 28-6-99).

Tin (Kalai) coated or copper vessels are good for health, it is also reported (News 3-6-03)

Colourful festival of Holi has also become unsafe because of the use of toxic colours! Black (Lead oxide), Green (Copper sulphate). Blue (Prussian blue). Red (Mercury sulphate) etc. contain heavy metals which cause skin diseases, kidney failure, eye damage and even cancer. Red powder Gulal contains lead, chromium, mercury, nickel, cadmium, zinc and iron which adversely affect kidney, liver, CNS, intestine etc. All India Institute of Medical Science and Poison Centre of the Central Govt. have also warned about use of these hazardous colours. Natural colours from plants and vegetables should be used. *Kesudo, Haldar, Limdo* etc. are of this group. (News 17-3-03)

CFC (Chlorofluoro carbon) generated from refrigerator and air-conditioner decreases oxygen level in air and in our body. Its result is hypertension, allergy, asthma and lung diseases. Detergent powder on clothes or utensils causes skin disease and more damage if ingested unknowingly. Xerox and laser printers liberate ozone gas. Anything which our nose or eye detects and dislikes, is primarily dangerous. Undetectable dangerous chemicals are also to be studied and avoided from our working atmosphere.

Scrap of outdated computers and mobile phones pose environmental risk. Monitors have heavy metals like Lead, Cadmium and Mercury and a poisonous gas Arsine. These metals release toxins. Therefore their landfills pose environmental hazard (News 10-7-2001).

Australian scientists, after studying two Australian and one British car shops for two years, invented that the smell of the new cars contain 83 mg/ m^3 Benzene (permissible limit 16 mg/m^3). A scientist Steve Brown told that long exposure to such poisonous substance causes headache, nausea, cancer and damage to the child in the mother's womb (News 29-12-2001).

As published in **Current Science**, 1 out of every 20 women in Mumbai has breast cancer! Doctors say that this figure could be still higher and may soon match that in the US, where I out of every 9 women has breast cancer. The magazine explains that this has direct relation with changes in life styles. It occurs as a result of uncontrolled cell divisions that invade healthy tissues and occur via blood stream or body cavities (News 6-1-98).

The world's worst terrorist attack on twin towers of the World Trade Centre, New York, USA, on 11-09-2001, has raised many questions of structural safety of such latest buildings, emergency preparedness to protect people inside such buildings, early detection and avoiding collision of aeroplanes to such high rise buildings, safety of pilots and air travellers, tight security checks for such highjack, isolated and fully protected pilots cabins, revised radar system to detect and avoid such sabotage etc.

Hazards of Allopathic Medicines are also disclosed. Made in and approved by PDA department of USA, a medicine known as REZULIN (drug for diabetes) killed many people in USA and Britain till it was withdrawn in May 2000! It was damaging liver and kidney both. Similar drug FENFORMIN was also required to be withdrawn. Another drug known as PROPULSID and used to control acidity has killed 103 people during the first 3 months of the year 2000. Still FDA gave licence to sell it till 14-7-2000. British Medical Journal has warned that every year 30,000 people die in Britain due to wrong prescription by doctors! (News 28-6-2000)

20 persons died at one occasion of *'Satyanarayan Katha'* on 10-9-2000 in a small house in Shyam Complex, at Surat due to fire and burn injuries. The causes published are (1) Solvent vapour from newly painted walls (2) Fire catching by synthetic sadies and (3) Alcoholic drink brought inside the room. Delayed treatment is also reported due to doctors on strike at Civil Hospital (News II, 12 & 16-9-2000). This incident stresses need of *safety in home* also (See Chapter 31).

Homes and buildings have been ruined to pieces 'in many earthquakes but the great earthquake of 26-1-2001 at Bhuj and other places of Gujarat have again shaken the whole world. The Govt. Reports published in February 2001 give the picture of this mishap: Death 18602, Injuries 1,66,385, animal died 20712, people affected 3.5 crores, estimated loss Rs.21262 crores, loss to industries Rs.5000 crores, fully broken buildings 2,28,906, partially broken buildings 3,97,538, talukas affected 49, villages affected 949, helping countries 38 and so on. *Has it not created many questions for the safety of buildings and safety, of people? Should we not rethink about our present pattern of high-rise buildings, flats, layout and planning? Is it not a sufficient lesson to realize a struggle of health v/ s wealth?* For safety measures in this regard see Part 2.3.4 of Chapter 31.

Report of the **'Soft drinks'** has also not come soft. The Earth Island Journal published from the birth place of 'Coca Cola' i.e. America, notes that in one bottle of such soft drink there are some 40 to 72 mg of intoxicating substances like alcohol, yeast gum, citric acid, glycerine and glycerol obtained from animal bodies. Citric acid content badly affects the bones and teeth, liver and intestine. Modern fast foods also invite bone diseases like 'osteoporosis' (News 30-6-2001).

Centre for Science and Environment, New Delhi, took 17 samples from Delhi, 13 samples from Mumbai and analysed in laboratory. Its Director Smt. Sunita Narayan told that level of pesticides found in these mineral water bottles was 36.4% more than its permissible limit of 0.0001 mg/l. More proportion of pesticides was found in more selling brands like Aquaplus, McDowell, Bislery, Volga, Kingfisher, Hellow, Baily, Finley, Purelife, Prime, Aquafina, Himalayan etc. DDT, linden, Melethion, Chloropirophose etc. were the pesticides. These can cause cancer and damage kidney, liver etc. When branded driving water is poisoned, what to say about safety of other materials? (News article, 13-02-03) Who worries for public safety? Based on inquiry following above report, the Govt. of India banned eight companies including Bislery and Pepsi and suspended their ISI quality mark on their water bottles (News 20-02-03).

A report of the same Centre for Science and Environment (CSE) published the presence of pesticides in Pepsi and Coca Cola brand soft drink bottles collected from and surrounding: Delhi. Four types of pesticides were found containing excessive proportion as under -

DDT	-	15% more
Lindane	-	21% more
Chloropyrifos	-	42% more
Malathion	-	87% more

Laboratory In-charge Dr. N.B. Mathur told that these pesticides can cause cancer and dissolve bones. Some pesticides are capable of decreasing sperm counts in males. The samples showed level of toxins as 0.0180 mg/l against the permissible level 0.0005 mg/l/ specified by the European Economic Commission. Mirinda lemon was found containing 70% more pesticides. *The Members of Parliament raised severe cry and insisted to prohibit such products in India. (News 0708-03)*

The companies have also published then replies in news papers (09-08-03) and denied such findings. Their defence is obvious because they don't wish to lose sales and profits. *One thing is certain that such drinks are neither energy foods nor essential for life. A one rupee product is sold at ten rupees. It drains our money to foreign countries. This is another hazard.*

Pollution Control Board of Kerala, took the samples of wastes thrown out by Coca Cola plant and after laboratory analysis it was found containing Cadmium 201.8 mg/l against the permissible limit of 50 mg/l. Thus even the waste of this plant was containing carcinogenic heavy metal. (News 08-08-03)

Coca Cola Co. has its plants all over the world including India. In Europe and USA, children and youths have made these drinks as part of their diet. In our country also, we see sale of thousands of bottles of Pepsi and Coca Cola at all -places. People should learn lesson from such eye opening news and give up such drinks hazardous to health

Health effects of Cold Drinks have been published. Ethylene glycol is used as antifreeze and anti-drying agent in such branded and non-branded bottles of commonly used cold drinks. It is a solvent and can dissolve our teeth and bone. In addition, it adversely affects our kidney, liver, lungs and CNS. Only 100 ml of Ethylene glycol is said to be a fatal dose.

Another major content of cold drink is Phosphoric acid, which is anti-rusting and analytical agent. Its TLV is only 1 mg / m^3 (STEL 3 mg /m^3) and damage stomach.

Carbolic acid or phenol is also used whose TLV is only 5 ppm and its absorption through skin is very fast. It affects CNS (brain), kidney, liver, pancreas spleen and lung. Its reported fatal dose is 1.5 g (oral It can cause cancer also.

Benzoic acid is used. as preservative whose lowest published toxic dose for skin (human) is 6 mg kg and causes gastrointestinal troubles..

Water used for soft drinks is from unknown sources and not hygienic. It contains heavy metals like lead, cadmium, zinc, sodium, potassium etc. and also reported to contain benzene and methylbenzene.

Therefore total avoidance or prohibition of soft drinks like Coca Cola, Pepsi, Thumps up. Sprint and so on is the only remedy for good health.

Soft drinks made from milk, fruits and vegetables viz. Lassi, Jaljira, Amla, Sugar-cane juice, Gulab, Khus, Ananas etc. should be promoted and used. (News 16-5-03)

After mineral water and cold drinks 'tin packed foods' are also declared poisonous. Inside metal, colours and chemicals are found toxic. Tin-food generates small bacteria known as 'C. botulinam'. This bacteria produces poison. Its fatal dose of only 0.12 micro gram can kill a person. In the name of permitted additive, emulsifier, stabilizer, colour and flavour, chemicals like vinegar, sulphur dioxide, nitrate, nitrite, anti-oxidant (eg. Buchilated hydroxi toluene), saccharine, monosodium glucomat are added. Therefore it is in the interest of safety to avoid such processed and tin-packed or plastic packed fruit juice, jam, bread, butter, cheese, ghee, tomato ketchup or sauce, vegetables, pickles, milk, soup, meat, fish, bear etc. (New 10-8-03).

A report published in 'Experimental Biology' states that **blood stored in PVC bags** becomes contaminated by a chemical known as DEHP contained in PVC. This harmful content adversely affects CNS, liver, kidney and red cells as it was detected from studies on rats. (News 07-08-03)

In the race of acquiring wealth and facilities, are we not doing a suicidal act?.

How many examples to cite? In short, our activities of acquiring wealth are constantly challenging our health. Therefore the concept of safety has become most essential.

3. INDUSTRIALIZATION Vs ACCIDENTS

Industrialization has been defined as 'the process of change in the mode of production to utilise more capital per unit of output, higher levels of technology and management, widening markets with cost economics scale and specialised location of plant, type of plant and labour skills'.

Side effects of such industrialization are to increase accidents, occupational diseases, polluted environment, unsafe working conditions and rapid urbanisation resulting in road accidents and vehicular pollution.

Accidents Facts, 1997, National Safety Council, USA, writes about increasing trend of accidents and injuries in USA as under:

"The un-intentional-injury deaths continued to increase for the fourth consecutive year in 1996 (86777 in 1992 to 98400 in 1996)... The toll of nonfatal injuries is also enormous. About 10207 million Americans need medical treatment every year due to work injuries. The economic impact of these fatal and nonfatal injuries amounted to $444.1 billion in 1996. This is about $1700 per capita or about $4500 per household".

"The five leading causes of such injury and death, which account for 80% of such deaths were unchanged in 1996. *Motor-vehicles, falls, poisoning by solids and liquids, fire & burns and drowning have been the top five causes since 1970"*.

The President of Indian Institute of Chemical Engineers, Ashok Panjwani, told at 49th Annual Session on 18-12-96 at Bharuch - "Industrialisation is the key for the growth of economy. However, growth at the cost of environment is proving to be *detrimental to the society*. There has been a tendency to forget the environment in the process of rapid growth of chemical industries".

"Safety has to be built into the culture. The safety standards of several organisations are equivalent to international standards but in many other industries *safety is still a slogan"*.

The industries increased after the first and second world war and with rapid scientific inventions and applications during the 20th century. The 20th century (1901 to 2000) historically earmarked for the constant rise of scientific inventions, researches, applications, industrialisation and mobility in every walk of life. It cannot be described in short. Here we are concerned with the impacts and ill effects of all such rising and roaring industrialisation as *unwanted evil* for the mankind.

Japan received complaints of environmental pollution and occupational diseases during 1957 to 1960 and it left such chemical industries soon after 1960 and turned toward electronics industry to keep its environment clean. Japan, USA and Canada were compelled to enact strict environment protection laws during this time, which we did during 1986 and thereafter. Our National Forest Policy of 1988 has failed to control environmental pollution. For healthy environment 33% land should be kept reserved for forests, which is reduced to 12% resulting in continuous decrease of birds, animals, vegetation, greenery and clean atmosphere for healthy life.

As per information up to 31-3-1998, total industrial investment in Gujarat was of Rs. 108777 crores. Out of that 54% was for production sector 'and 22.08% for power. 57000 crores was to be invested in petrochemical and chemical industries. Bharuch, Surat, Vadodara and Jamnagar would become the highly industrialised areas. An industrial park at the cost of Rs. 1000 crores was to be sanctioned by the Govt. of Gujarat, to establish chemical and petrochemical industries at Motiberu, near Dholica, Dist. Ahmedabad (News 6-11-97).

In Gujarat 2435 new projects involving Rs. 1250 crores were under various stages of implementation during 1997-98. SSI units increased up to 194000 till the end of 1996. Present installed power capacity of 7721 MW will be raised to 15000 MW at the end of 9th Five Year Plan. Gujarat may secure leading position as industrial state among the Asian countries in the 21st century (News 25-12-97).

Gujarat Infrastructure Agenda: Vision 2010 occupied a full-page advertisement on 27-6-4999. It states 383 world-class infrastructure projects of Rs. 116993 crores! Till 2010 it is planned to have 17477 MW electricity at the cost of Rs. 55167 crores, transportation of 289 million ton cargo at ports, 24 new industrial estates (including 10 port based industrial estates) at the cost of Rs. 7161 crores, 105 new roads with Rs. 19951 crores, 38 new railway projects with Rs. 6533 crores, 49 new water and gutter schemes, II new townships, 51 new systems of urban transportation, 1507 km long gas-grid, new air ports and information technology facilities of Rs. 400 crores. This blueprint of Gujarat, if implemented, will certainly increase rapid industrialisation and in turn safety problems too! It indicates high need of safety technology and accident prevention work.

With such rapid industrialisation, roads and. traffic will also increase. A scheme of Rs. 1400 crores -to develop highways in Gujarat has been sanctioned by the Government (News 1-11-97). Expansions of KRIBHCO plants to produce 1350 MT ammonia and 2200 MT urea both at Hazira and Gorakhpur, at the total cost of Rs. 2314 crores was announced on 6-1197 (News 7-11-97). Such continuous industrial expansion and increasing hazards also increase the need of safety.

It is also reported that only because of the high hazard potential, Vadodara will become the country's headquarters for disaster management. A central control room - the only one in the country - for managing disasters will be set up (under UDMP) there (News 7-10-97).

During last ten years, industries, workers, raw materials, products, pollution, transportation of men and material and their hazards have been increased tremendously. The Central Statistical Organisation (CSO) has reported that industrial production during first four months of 1997-98 was increased by 6.4% comparing with the same period of 1996-97.

The courts are constantly issuing orders to close down the polluting factories. It has also directed to use some less polluting fuel like pentane to decrease vehicular pollution. Looking to the increasing trend of road accidents and falling of school buses in river, the court's directives regarding traffic rules have been shown on TV.

The road accidents are .also increasing as a result of side effects of growing industrialisation and urbanisation. Some figures are as under:

As per report published in 2002, 'India is at No.1 in the world in the matter of road accidents. Sixty thousand people died due to road accidents last year.' (Editorial 18-12-02).

As per report published on 7-2-97, every year some 3 lakhs road accidents take place in India in which more than 60000 people die and @ Rs. 35 crores economic loss results. 20 Lakhs two-wheelers were reported only in Delhi on 1-11-97. From this very day, the helmet was made compulsory in Delhi for all back-riders on two-wheelers. Why? for the purpose of safety only.

The year 1997 was celebrated as Road Safety Year in Gujarat and it is reported that during this year the figure of average daily accidents raised to 95 from the similar figure of 83 in 1996. Figure of daily average fatal accident was also increased to 15, which was 13, in 1996. During first 9 months of 1997 the total road accidents were 25247 out of which 4062 were fatal. Around 50% fatal accidents occurred on highways (News 6-2-98).

In the year 2002, in Gujarat, 4178 people died and 22000 injured due to road accidents (News 13-01-03)

Some figures of road accidents are as under

Road Accidents in Gujarat

Year	Total Accidents	Fatalities	Serious Accidents
1991	27457	3760	5540
1992	26745	4010	6093
1993	27115	4219	6833
1994	26132	4051	6020
1995	30111	4871	7386

Road & Factory Accidents in India (LP News)

Cause	1990	1991	1992	1993	1994	1995
Road accidents	43005	44930	49156	45769	51855	68351
Factory accidents	658	539	549	550	606	616
Others						
Fire	20522	22306	22010	22395	23323	22922
Poisoning	13164	13697	12773	13134	13752	20135
Electrocution	2957	2933	3062	3488	3502	3861

Accidents on National Highway

Years	Total Accidents	Deaths
2000	110000	>30000
2001	100000	>29000

In addition to road accidents/another hazard from vehicles is lead poisoning from their *fuel exhausts*. To avoid this, unleaded petrol, LPG and CNG are introduced.

For more figures of road accidents, see Chapter-31.

In rail-accidents also India is not behind. Two out of five world-worst rail accidents have occurred in India. More than 800 people were died in June 1981 in Bihar when a train fell down from a bridge into the river. A head-on collision, a rare occurrence on a double-line section happened at 1.55 a.m. on 2"d August 1999, between two express trains Brahmaputra Mail and Avadh-Assam Express - at Gaisal (North Bengal) railway station. 278 passengers were killed including drivers and assistant drivers of both the trains. Over 500 were badly injured. A statutory inquiry into the cause of the accident by Chief Commissioner of Railway Safety, Mr. M Mani, was announced.

Some notable rail accidents are as under :

Date	Place	Fatality
25-06-90	Mogta, Bihar	60
05-09-92	Raigadh, MP	41
16-07-93	Darbhanga, Bihar	60
21-09-93	Chhabra, Raj.	71
14-05-95	Salem, TN	52
20-08-95	Firozabad, UP	302
18-04-96	Gorakhpur, UP	60
14-09-97	Madhya Pradesh	81
26-11-98	Ludihana	108
16-07-99	Matura	17
22-06-2001	Kozikode, Kerala	40
09-09-2002	Bihar, Rafiganj,	120
03-01-2003	Ghatamnagar, M'rashtra	21
15-05-2003	Punjab, Fire	38

All such accidents denote safety problems and call for preventive measures. The Federation of Railway Officers stated that the political leaders are extending railway services without worrying for safety. (News 27-9-97)

471 rail accidents during one year, 1998-1999, (1.5 accidents per day!) and 2000 rail accidents during 1993 to 1998 tell us the story of railway safety! Internationally accepted latest computerised Auxiliary Warning System (AWS) cannot be applied to a large network of 62000 km rail track in our country, said the Railway Board. This technology costs Rs. 1 crore per kilometre (News 9-8-99). More attention on human errors and good maintenance of prevailing safety system remains the only remedy. This is the abstract of some 2000 reports submitted to the Railway Ministry indicating 40% accidents due to human errors!

The retired SC Judge Shri H. R. Khanna, Chairman of Railway Safety Review Committee, submitted its report to the Railway .Board. This report outs stress on radio communication facilities, safety and warning systems, train actuated warning system, axle counters, flasher lights, emergency provisions in engines, modern track data recording system, reducing human element and increasing quality of training and education to all types of railway employees including drivers (News 30-8-99).

'Anti collusion device prepared by Konkan Railway will be fitted to all the trains', said the Railway Minister Shri Nitish Kumar (News 11-10-2001)

In an accident between a goods train and a passenger train at south Mozambique, 20(1 people died and 200 to 300 injured. Aeroplane bowing 747 burst into the sea near west seashore of Taiwan and all 225 passengers died: (News 26-5-02)

234 air-travellers died in a plane crash in Indonesia on 26-9-97. The great jungle fire in Indonesia caused a heavy loss of environment in hundreds of kilometres and for days together in September 1997.

Regarding urbanisation, Warner Foreno, the President of Population Institute at Washington, reported "the half of the world population lives in cities and towns" and it was also predicted that by the end of the year 2050, two-third of the world population would be found in cities. This will create urban problems. (News 31-12-2000)

Thus increasing industrialisation, urbanisation and transportation are causing accidents and dangers to human life. Fatal Road accidents' of 1995 occupy 34.02% of total fatal accidents of that year. Factory and machine accidents (fatal, 1995) were only 0.31%.

The Report of the **Indian National Commission of Labour** said in 1969:

"In a country as populous as ours, there can be danger of a tendency developing to discount the value of human life. Its loss in accidents or through the slow and agonising process of an occupational disease may not stir the community as much as it could be in countries with chronic labour shortages, though to the near ones it is a tragic occurrence. Relief gets organised after the event, but prevention gets side-tracked ".

This observation describes the accident problem and suggests the remedial measure that prevention should not be sidetracked. This emphasizes the concept of safety.

Effects of industrial sickness on safety:

The worldwide recession, globalisation and international quality competition may retard the industrialisation described so far. However, big chemical complexes may generate more and more opportunities for safety professionals. Small-scale units shall have limited scope. Due to globalisation, automation and computerization, the employment may not increase as per expectation.

The Labour Department of USA has declared that the unemployment rate has been increased to 6.4% in the last month. This is the highest unemployment rate of last 10 years. Many people are in search of jobs but they do not get employment. (News 11-07-2003)

Unemployment rate in Saudi Arabia is reached to 12% and therefore its Government decides to retrench 17800 foreign workers and has advised them to leave the country within one month. (News 18-07-03)

Planning Commission of India reports: 'Employment growth rate has been reduced from 2.00% to 0.98% during last six years'.

Observation of **National Sample Survey** says that 'When the GDP increased from 5.8% to 6.7% (industrial growth), the employment growth rate was decreased during 2001-02.

The employment growth rate of public sector was decreased from 0.10 to 0.03%.

At the end of the year 2002-03, in Gujarat, a figure of unemployed literate persons was about 9 lakhs (as per Employment Exchange Office) and this may become 40 lakhs in year 2010. (News 16-07-03)

Thus industrial and employment retardation, worldwide recession, financial hardship and effects of globalisation may retard the movement of safety in our country (News 22-5-2001).   .

Industrial production has been increased but employment opportunities have not been increased proportionately. Some 6 lakhs industries and factories have been closed down. As a result, lakhs of workers have become unemployed. The State of Kerala stands first in literacy rate but however the unemployment of literate people is also the highest in that state.

Comparing with the metro cities, unemployment in villages has been increased. Due to the ill effects of Government policy, condition of agriculture and small and cottage industry has been worsening. It has resulted in unemployment in villages too.

More and more workers from organised sector are being thrown in unorganized sector. Therefore, economic imbalance, people living below the poverty line and unemployment are continuously increasing. This is the sad scene. (News 11-6-03)

When industries become sick, manpower decreases, automation increases, the cost of everything goes on rising, trade union activity diminishes and Govt. policy not boosting the industry, how an employer will think of safety, a non-productive factor for him? When question of survival comes, many factors like employment, safety training, HRD, welfare and other facilities may go away and scenario will be of retarding from our important commitments toward safety. ILO conventions and recommendations, statutory provisions and legally awarded health and safety measures may remain on paper only.

Let us try to change this hazardous situation, reverse the retardation and try to prosper industry, employment, safety awareness and healthy atmosphere everywhere.

Let us hope, new industries will come, employment will increase and work of safety professionals will also increase.

4. DERIVATION OF THE CONCEPT OF SAFETY

Thus from the above discussion of struggles of –

1. Dead Vs. Live resources,
2. Health Vs. Wealth and
3. Industrialisation Vs. Accidents,

- and from the reply of following questions:

1. What are more important? Dead or Jive resources? A machine or its creator? A material or its user? Money or its beneficiary?
2. Should people die or meet with accidents in a race for wealth?
3. Should hazards and risks be ever increased with the growth of industries?

- What ultimately derived is the need, importance and fundamental understanding of the ***'Concept of Safety'*** only.

People want both-dead and live resources, health and wealth and industrialisation and employment - but nobody wants accidents. This becomes possible if and only if the concept of safety is understood and followed.

To maintain safety of people and to follow safe work practices in safe working conditions is the only way to prevent and control the hazards of environment (including industry). Therefore it is most important to realise, study and apply the concept of safety in every walk of life, particularly in industries.

Following this basic concept of safety, the concepts of total loss control, total loss prevention and hazard control technology have been developed. .Risk assessment, safety audit, various engineering, medical and administrative safety measures are developed and followed to implement this concept of safety.

Technology Advantages to be utilised:

It is this concept of safety only, which is worldwide controlling and trying to decrease accidents and injuries. Though the increasing trend of industrialisation to increase living standard of people, may increase risks, accidents and losses, yet the progress of the same science, technology, industrial hygiene, and engineering may, on the other hand, help to eliminate or control those hazards and therefore this second aspect of the Safety Technology should be fully utilized.

The science of safety engineering, control technology and techniques of modern management have been advanced as under.

Antidotes have been developed for protection against health hazards. Microwaves and laser technology have eliminated high frequency hazards.

Linear motor train running at 451 km/h by electro-dynamic levitating force, thrust SSC car running at 1223.28 km/h, generation of bio-gas (fuel) from rotten vegetable waste and use of its residual waste as a cattle-food, fuel-cell to convert petrol into hydrogen to reduce vehicular pollution, French technique to get a desired baby, human cloning by a somatic cell and genetic engineering (first clone female baby borne on 26-12-2002, 11:55 a.m. at Florida, USA), fully automatic eye function controlled camera (camcorder), digital mobile cell-phone, motorised electric toothbrush and a ship-cum-plane (wing-ship) which can swim on the sea and fly in the sky have been invented.

Tele-presence technology has been developed to remotely carry out surgical operation on a person flying in a plane or sailing in a ship. Early detection of breast cancer from the hair sampling (change in molecular structure) has now become possible. Telecomputing, telemedicine and tele-shopping systems have also been developed. Not only e-mail, inter-net or website but v-mail will also become older in course of time. Robotic controlled systems of atomic plants will now be controlled by a newly developed tele-manipulator system (News 24-8-99).

New inventions of 3D Sonography and Bio-diesel are also reported.

The landing of a robotic spacecraft from earth, Pathfinder, on 4-7-97, on the red planet Mars, the launching of IRS-ID (Indian Remote Sensing Satellite) into an 817-km polar sun-synchronous orbit by our fully indigenous rocket PSLV (Polar Satellite Launch Vehicle) on 29-9-97 from Shriharikota island, successfully test-firing of the anti-tank Nag missile, another indigenous development, on the same day,. from Chandipur in Orissa, launching of another Satellite INSET-2E by ISRO on 3-4-1999 and remote robotic surgery on human body have proved the success of science and miracle of safety engineering in overcoming hazards, their correct assessment and control.

News of replacement of highly toxic chemical pesticides by non-toxic bio-pesticides is a good march towards safety. Gujarat Krushi University has made, for the first time, large-scale recommendations in this direction. An abstract of nimb leaves, tobacco dust, biolep, spinosed, cow-urine etc. have been specified and submitted as a report to the State Assembly (News 13-3-03).

Smoke of cow dung and ghee remove air pollution. Three insects - Dhaliu, Bhamari and Papati - known by our farmers, are non-chemical bio-insects to kill harmful worms and eggs in the farms. (News 1-7-03)

By non-chemical farming, a farmer got 7 ton more crop of sugarcane per hectare with less expenditure (News 18-3-03).

The same ultra modern technology is to be utilised for safety also.

Safety efforts of improvement in safe design, safe operation, safe preventive and corrective maintenance, safer technology, safe equipment and instruments and safe disposal of wastes are giving positive results. Thus the implementation of concept of safety has been proved fruitful.

5. NATURE OF THE CONCEPT OF SAFETY

History of the Concept of Safety is very old. Though the word Industrial Safety can be said to begin with the 19th century as textile mills and other industries started in England after the year 1800 and establishment of Factory Inspectorate in 1833.

The Concept of Safety has the oldest history in our country and subsequent development in foreign countries. It is explained below.

5.1 Age-old Concept: Indian Origin:

We are proud of our old heritage as it supplies almost all origins in all walks of life. It requires efforts to search it. Our Vedas, Kamayan, Mahabharat, Shukraniti, Kautilya's Arthshastra (Rajniti), provide valuable advices on industrial matters, c`gLifr] ;kKoDy;] ukjn] euq] 'kqØ] dksfVY;] fo'odekZ] Hkh"efirkeg] nzks.k] etc. are the great Indian seers who had explained the Labour Code from time to time. Their advice was according to their prevailing time and putting more stress on duties rather than on rights.

The basic concept of safety for human protection is explained in Rugved (6-75-14) by the following sentence-

iqeku~ iqekal% ifjikrq fo'or% !

Let man protects man every where in the world.

It is also said: /keksZ j{kfr jf{kr % which means Dharma, a divine force to govern all people by self-discipline, will protect them who protect themselves. Thus it is the primary duty of all of us to protect ourselves. This is the foundation of safety philosophy. The same theme of protecting one another on the strength of Dhrama (righteous behaviour) is also explained by:

u jkT;a uSo jktk·lhr]
u n.M;ks u p nkf.Md % A
/kesZ.kSo iztk los
j{kfUr Le ijLije~ AA

What were the hazards of ancient time from which men were seeking protection from God is well stated by:

j{kkafl ;=ksxzfo"kk'o ukxk%
;=kj;ksnL;q cykfu ;= A

nkokuyks ;= rFkkfC/k e/;s
r=fLFkrka Roa ifjikfl fo'oe~ AA

O Mother Goddess, thou protect us from serpents having lethal poison on their tongues, powerful enemies and robbers, great fire, and depth of the sea by being there and surrounding the world.

People were advised to exert cgqtufgrk;] cgqtu lq[kk; and they were in fact loZHkwrfgrsjrk% A

u Roga dke;s jkT;a u LoxZ u iquHkZoe~ A
dke;s nq%[krlrkuka izkf.kukekfrZuk'kue~ AA

It is neither political power, nor heaven, nor even rebirth that I aspire for. My only aspiration is to relieve all affected beings from their pain or suffering.

The well-known Upnishad advice runs as -

losZfi lqf[ku% lUrq losZ lUrq fujke;k% A
losZ Hknzkf.k i';Urq ek df'pr~ nq[kekIuq;kr~ AA

Let all be happy and healthy. Let all achieve welfare and no one gets any unhappiness.

Happiness cannot be achieved without safety and good health. Therefore above stanza speaks of safety, health and welfare of all, which is also the modern concept of all the safety laws.

lgukSvor~] lgukS HkquDrq and lgoh;a djoko gS
also tell that let us come together, suffer together and work together. This prayer is always useful to keep us on the way of safety.

The definition of Hkjr by whose name this country named as Hkkjr (Bharat) is Hkj.kkr j{k.kkr p~ was called Hkjr because he was maintaining and protecting. Hkkjr means the country to maintain and protect her people. Thus very name of our country contains the concept of safely. The king was said father only because he was giving protection, provision, education and livelihood. This basic duty of modern State ensures the concept of safety and welfare.

One of the definitions of nation, as given by Yajurved (22-22), calls for ten components which also include warriors to protect the country, best and ample weapons, enough load carrying vehicles and healthy and prosperous life. This Vedic concept is nothing but the concept of safety, health and protection of lives.

The basic safety of 'prevention is better than cure' is well explained as follows:

fpUruh;k fg foinkeknkoso izfrfd;k A
u d`i[kuua ;qDra iznhIrs ofguk x`gs AA

The reaction (preparation) should be thought before an emergency arises. It is of no use to dig well when fire has already ignited the house.

How an accident can or cannot save human life, is interestingly explained by:

vjf{kra fr"Bfr nSojf{kre~
lqjf{kra nSogra fou';fr A
thoR;kukFkks·fi ous folftZr%
driz;Ruks·fi x`gs u thofr A

An unprotected is protected by fate. A well protected but hurt by fate may be ruined. A person lost in jungle and without any help may survive. A person making all efforts in his home and surrounding with doctors (having all helps) may die.

Kautilya's Arthshashtra :

¼dksVyh;e~ vFkZ'kkL=e~½ The age-old Kautilya (Vishnugupta Chanakya)'s Arthshashtra (economics) is a big volume of old Indian rules on economics, politics and sociology which covers many 'subjects on trade, business, industry, commerce, administration, law and order, justice, architecture, design, construction and winning t)f forts, town planning, army etc. in those days. It has 180 chapters and 6000 stanzas. It has been translated in many languages.

This volume talks of atom's size, weights and measure, metallurgy, mines, metal processes, wood, lather, and other processes, agriculture, weapons, cotton, wool and dyeing processes, medicine and surgery, protection from fire, water, diseases, animals, natural calamities and so many things in a systematic way. A few references are given below:

nSokU;"VkS egkHk;kfu A
vfXu:nda O;kf/knqZfHk{ka ewf"kd% A
O;kyk% likZ% j{kkalhfr A
rsH;ks tuina j{ksr~ A

'Fire, water, diseases, scarcity, rats, wild animals, serpents and demon are eight great dangers. To protect people from these is a duty of the king.' Kautilya has explained problems as well as solutions.

A king (ruler) is advised to protect the people from enemies, bad workers, traders, act of God, antisocial elements, thieves and robbers, poisons, and many other things.

He had described many fixed and movable machines ¼fLFkj;a=kf.k py;a=kf.k½ to be used 'in war. He had described the metallurgical processes on gold, silver, copper, alloy, stone, iron, diamond, jewel, salt, etc., with safety precautions.

General philosophy for protection is explained as follows:

vkRefu jf{krs loZ jf{kra Hkofr A

Protecting our self we can protect all.

n.MuhR;kek;RrekRej{k.ke~ A

Our self is protected by rules of punishment, i.e. n.Muhfr A

nSoa 'kkafrdeZ.kk izfr"ks)O;e~ A

Natural hazards should be prevented by good efforts.

ekuq"kh dk;Zfoifra dkS'kysu fofuokj;sr~ A

Manmade hazards should be removed byskill and intelligence.

'k=ksjfi fof'k";irs O;kf/k % A

A disease is worse than an enemy. Therefore it should be prevented at the earliest possible.

'kkL=iz;kstua rRon'kZue~ A
foKkunhisu lalkjHk;a fuorZrs AA

The purpose of any science or literature is to give real knowledge of the things. This indicates the purpose of safety science, 'which removes the apprehension of the world.

The basic intention of all such rRon'kZue~ (realisation of element) is for the benefit, subsistence and protection of the earth (i`fFkO;k ykHks ikyus p) and humanity.

Warning for working against environment or nature ¼izdfr½ f.k is also given by:

lzdfrdksi% loZdksis{;ks xfj;ku~ A

Anger or revolt by environment is the highest of all angers!

The best advice is given by following Words.

U Roga dke;s jkT;a] u LoxZa u iquHkZoe~ A
dke;s nq%[krIrkuke~] izkf.kukekfrZ uk'kue~ AA

I have no desire of any kingdom, haven or even salvation. I simply desire to remove affliction or suffering of people hurt by agony or pain.

This is the object of protecting others, the best of philosophy of safety.

5.2 Age-old Concept: Foreign Origin:

Safety being the human instinct and basic need of mankind, its origins are universal and found everywhere in the world, whether they are reported or not. In Chapter-33 of History of the Safety movement, chronological order of concept development is given. Only an excerpt is given below.

'Prevention is' better than cure', 'Health is wealth' and 'Sound mind in a sound body are old and universal safety concepts. 'An injury prevented is a beneficiation, an injury compensated-an apology' is also an old quotation.

Risks and life are inseparable. In order to survive, man has acquired through the ages, instinctive habits and reflexes to protect him from the more common hazards. A man picking up a hot stone instinctively drops it before serious injury occurs to his hand.

Safety and science -are also inseparable. History of safety begins with the history of science. A man of an ancient era accidentally invented 'fire' and its uses. Fire safety began since then. Protection of self and family from heat, cold, rain, wild animals and enemies is an age-old concept of safety. The homes of cliff dwellers, pyramids, ancient Chinese tapestries, Indian. swords, metallurgy, architecture, woodcraft, mathematics, chemistry and similar antiquities attest men's industry thousands years ago. Because of his desire 'for self-preservation and fear of injury, the concept of safety was existed in the earliest civilisation. But earlier efforts were personal and defensive. The modern concept of organised safety started with the machine age.

Plato (BC 427-347), Gutenbarg (Printing Press in 1456), James Watt (Steam Engine in 1765), Eli Whitney (Cotton Gin in 1793), Isaac Newton, Thomson, Robert Fulton (Steaul Ship, 1807), Stevenson (Railway Engine, 1814), Michael Faraday, Thomas Alva Edison (Electric Bulb, 1879) are some earlier notable scientists who laid foundation of the machine age.

The *Ebers Papyrus* and the *Edwin Smith Papyrus* dating from @ 3000 BC (found in 1862) are the first written document on health and safety. They discussed about injuries and treatments involving splints, dressings and ointments.

Babylonian code of Hammurabi @ 2000 BC describes, "If a man strikes another, he shall be responsible for the physician." It is a code of some 280 paragraphs and covers bodily injuries and workers' compensation laws.

In @ 1500 BC Ramses III hired physicians to care for **mine and quarry workers.**

In @ 400 BC, Hippocrates, known as the father of medicine, described tetanus; About 200 BC, the Greek poet and physician Nicander described the effects of **lead poisoning.**

About 200 BC (found in 1898) a wooden aircraft model (length 6" x wings 7") was made which is kept at the Museum of Antiquities, Cairo, Egypt. Right brothers made, a simple balloon in 1903 i.e. some 2100 years later. Bhagvan Ram's **'Pushpak Viman'** was an invention much earlier than that.

An electric **dry battery** made in Iraq some 200 BC is kept in a museum at Baghdad. An astronomical clock made in 65 BC was found in 1900. All this indicates age-old concept of science and safety.

From 100 BC to 2nd century, various Roman writers described the plague of Athens, the ill effects of their environment on mine workers and un-healthful effects of lead for water piping and wine containers.

In 7th century in Lombardy, King Rothari codified the existing laws in 388 chapters on principles of compensation for injury. This work continued in 11th century also. In 1473, Ulrich Ellenbag, an Austrian physician warned about hazards of metal burning. George Agricola's book, in 1561, described air venting in mines and use of gloves, leggings and masks. In 1567, Paracelsus, published an article 'On the Miners' Sickness and other Miners' Diseases' wherein he distinguished between acute and chronic poisoning. In the early part of the 18th century, Ramazzini published 'Discourse on the Diseases of Workers'. He added one more question to patients: "What is your occupation?" He is called the father of occupational medicine.

Spinning jenny, power loom and cotton gins were discovered in 1764, 1784 and 1792 respectively. Industrialisation (mass production, mills) started in Britain in 18th century and spread to the Continent and USA.

In 1804, President Thomas Jefferson delivered his safety message to Captain Merewether Lewis at the start of the expedition (1804-1806). He talked of danger, risk and safety of the people.

In England Government factory inspectorate was established in 1833, and 'Great Factory Act' was enacted in 1844 to provide fencing for mill gears and shafts.

In 1833, George Stephenson suggested use of a steam whistle on locomotives. In 1866, first National Board of Fire Underwriters organised. In 1881, first Indian Factories Act was introduced in India. In 1900, first safety periodical named Safety engineering (presently Safety Maintenance) was published.

In 1903 demands of industrial workers were considered in Russia. In 1913, National Safety Council was founded in USA. In 1914 first safety of life at sea convention held in London and in 1918 first Air Mail Service started. First World War (1914) and Second World War (1939) accelerated the industrialisation and the need of safety. In 1919 ILO was established at Geneva and in 1921 it set up a safety service.

US Census of 1900 showed 1750178 working children between 10 to 15 years. In 1867, Massachusetts had begun to use factory inspectors and 10 years later that passed a law regarding safeguarding of hazardous machinery.

The concept of safety was well explained by the President of USA before the National Conference on Industrial Safety as follows:

"The plain fact is that our Nation cannot afford the needless loss of skilled workers if we are to produce for prosperity in this country and for peace abroad."

5.3 The Concept Described:

The concept of safety has been developed as a basic need of human protection. It is obviously and essentially necessary to protect lives of human beings and all living creature from natural and manmade hazards and to prevent the property losses for an economic interest also.

For this purpose, the concept includes various methods of hazard detection, inspection, analysis, measurement, assessment and application of safety measures. It includes all aspects of accident prevention and control,, occupational health & hygiene and environmental protection (pollution control). In this context, it is a broader concept of international acceptance and most vital for our present life and the life of our future generation.

In spite of all efforts of prevention, accidents do happen and therefore the concept of safety includes all control measures to mitigate the aftereffects of any accident, injury, death or emergency. In this sense, the concept of safety is inclusive of all hazards and risk control techniques, research and application. It also includes safety information, education, training, supervision, public awareness and involvement programs and statutory measures necessary from time to time,

Therefore the concept of safety can be described as follows:

It is an age-old concept as well as always advancing. It is basic as well as specific. Basic concept means all basic, general, fundamental and primary safety rules, while specific concept includes specific safety knowledge to solve specific safety problems. The concept is technical, engineering, scientific, physiological, psychological, methodological, managerial, experimental, ergonomic, qualitative and quantitative. Its branches (area of work) are many. Industrial, space, road, rail, sea and home safety are the main branches. Mechanical, electrical, chemical, health and hygiene etc. are sub branches. Its coverage is very wide. It is not any single branch of science and technology but it includes branches of science, engineering, technology, health, hygiene, medicine, philosophy, psychology, management etc. It includes all statutory and non-statutory safety measures. It has, now, also developed as a separate specialised branch. Thus the concept is like a 'Diamond concept' having many facets. See figure 1.1

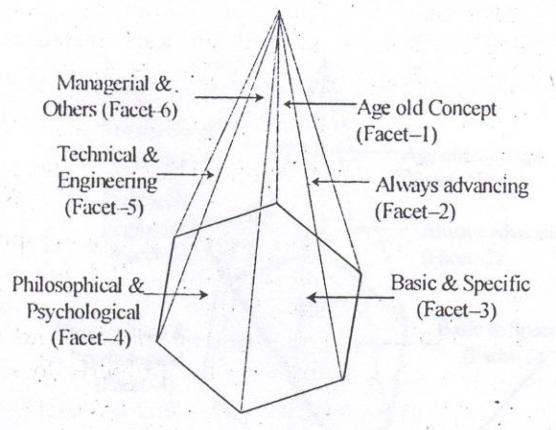

Fig. 1.1. Diamond Concept of Safety

The concept of safety is a broader concept and not limited to an accident prevention work only. In its true parlance, looking to the definition of environment the term Environment Safety includes occupational health and hygiene, pollution prevention and control, philosophy and psychology of safety, principles of management and all techniques of hazards detection, prevention and control technology, if hazards are prevented or controlled, risks will not arise, if risk is prevented, accident will not arise and if accident is, thus, prevented, accident is, thus, prevented; death, injury, damage and losses will not arise and that is the target of our concept of safety. If its engineering part is practiced from design to discharge level, less help will be required of its medical part. Production technology should be reinforced with the safety technology. If this much is understood, the concept is clear and to the point.

The concept of industrial safety began as *accident prevention*, widened as *Occupational health and hygiene* and gas reached up to the level of *Environmental protection*. But as the majority of the hazards are concentrated in industry, the term *industrial safety* is more prevalent. See figure 1.2

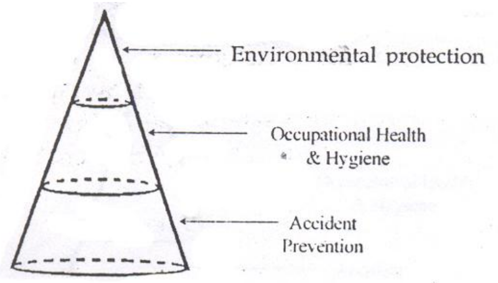

Fig 1.2. Three Stage Development of the Concept of Safety

Thus Industrial safety includes three things- accident prevention, Occupational health and Environment protection.

Industrial Safety can thus be defined to mean 'Protection of environment from hazards of an industrial activity.' Here 'environment' includes workers, public plant, property, land, air, water and their interrelationship. Industrial activity, includes storage, process, transport, transfer, use, handling or dealing with all materials (including raw materials, products and wastes), plants and machinery, land and building piping and equipment etc.

The concept of safety is philosophical because it is a way of thinking and searches for 'why' and how the root and the ultimate aim of safety. Philosophical of safety is explained in Chapter- 2

It is psychological, because it studies human behavior in much detail as a root cause of accident responsible resource for accident prevention and as a subject of safety. It keeps human as a centre for protecting from hazards. see figure 1.3 that is why the occupational safety is also termed as *Human engineering* psychology of safety is explained in chapter – 3

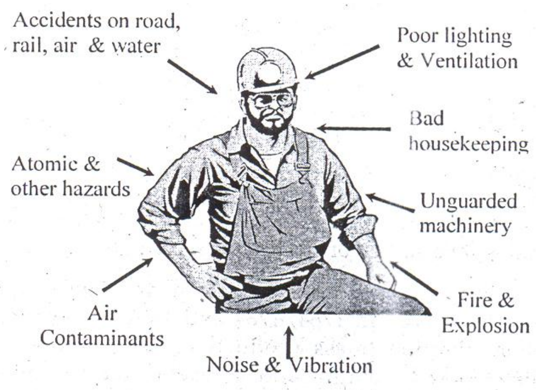

Fig. 1.3 : 'Man' is to be protected from Hazards

It is analytical, because it examines minutely the elements of accident occurrence and always tries to prevent its recurrence. The concept emphasizes on causation analysis and appropriate remedial measures based on that analysis. The accident causation and prevention is explained in Chapter- 4

It is quantitative, because, it insists for safety statistics costs of accident, budgeting, of safety, measurement of safety performance, safety limits, safety indices, values, marker, records and full data on all safety subjects. Statistics of Safety is explained in Chapter – 5

The concept of safety has also been developed as safety management systems. Many safety management programs have been developed. Safety department now occupies an important role in industry. Safety policy, safety committee, safety officer, safety training etc., are given due weight-age. The safety management is explained in Chapter – 6

The concept is universal i.e. equally important for all living creatures in the universe and includes all areas of activities everywhere. Therefore the concept of safety in a variety of subjects is subsequently explained in rest of the Chapter 7 to 33.

5.4 The Concept of SHE or HSE:

Above discussion of concept of safety in part 5.1 to 5.3 reveals that the word Safety has very old origin since centuries. The aspect of Health i.e. safety of health or safety from health hazards was added from 200 BC when the un-healthful effect of Lead poisoning was noticed. The last phase of **Environment** safety is added from the 20th century when the developed countries like UK & US first experienced the ill effect of environment pollution and the laws for the protection of environment were found necessary. In our country, the first law for water pollution control was enacted in 1974 and more laws were added since 1986 with the beginning of Environment (Protection) Act. 1986.

Thus the concept of safety does not remain limited to a narrow meaning of safety as accident prevention work from mechanical or machinery hazards only. As stated above, in course of time, it has included many aspects of safety from health hazards due to chemicals, other materials and their processes and safety from environmental hazards mainly due to pollution of land, water and air, thus the modern concept of safety has been developed as the concept of Safety, Heath and Environment i.e. SHE, HSE or EHS. Therefore in modern industries, the Safety Department is re-designated as 'SHE or HSE dept' and it carries our combined functions as under :

1. Main function of SHE Department is to plan. Execute and coordinate the specific function of Safety Manger, OHC Head or Factory Medical Officer and Environmental Manager

2. Function of Safety Manager and his office (subordinate safety officers and staff) are many but broadly they should include-
   a. Duties mentioned in Rule 6 and 7 of the Gujarat Safety Officer Duties, Qualifications and Conditions of Service Rules, 1983 (For details see Part 8.2 of Chapter – 6)
   b. Safety Managerial functions as explained in Part 6 to 12 of Chapter – 6 Such functions include plant visits and carrying out scheduled inspections and safety audits, meetings, including safety committee's meeting, accident-incident- near- miss investigation, HAZOP study, HAZAN, risk assessment, statutory compliance, development and updating of safety documents including SOPs, work permits, safety instructions for workers and public, training programmes, PPE and other safety equipment, rehearsal of emergency plan etc,

3. Function of Factory Medical Officer or OHC should include -
   a. Statutory medical examinations and reporting as mentioned in Gujarat Factories Rules, particularly in schedules u/r 102 and rule 68 R, T & U.
   b. First aid training for workers and
   c. Other training programs on industrial health and hygiene.

4. Functions of Environmental Manager and his office are day by day increasing due to enactment of more and more laws and guidelines issued from time to time from MoEF and GPCB/ CPCB. They include-
   a. Provision and maintenance of ETP and air pollution control devices to keep under control all pollution parameters prescribed by law and legal offices.
   b. Taking regular samples of water, air, stack and other emissions, noise level etc., to analyze them in laboratory, to record them in prescribed forms and to report to the authorities.
   c. Making arrangement of consultancy services if required.
   d. Arranging training programmes on environment safety.

Therefore now-a-days some companies require officers possessing combined qualification in safety and environment e.g. Post Diploma in Industrial Safety and also such diploma in environment to carry out above functions of SHE department.

6. NO EXCEPTION TO SAFETY

Thousand of examples and detailed discussion so far reveal that we have no exception to safety i.e. there is no substitute for safety, Results of undermining safety are very bad. One example can be cited as under:

Burning and breaking of space shuttle 'Colombia' of NASA and death of seven astronauts on 1-2-03 compelled accident inquiry. News report from New York disclosed that five members panel and two consultants were removed from the service who had earlier pointed out the safety problems in space shuttles and advised to increase the NASA budget for more safety measures. It was also reported that NASA had ignored the advices. Warnings and inspection remarks and long-term safety measures suggested by panel experts. The result was the death of seven young persons loss of 2000 crore dollars, space shuttle and other property loss of many million dollars! *Is it not a huge cost of undermining safety? Is it not eye opening and alarming for all of us to pay prompt and proper attention on all matters of safety? Let its do that.*

The present status of unsafe working conditions polluted environment and deteriorating health, explained earlier, make us unhappy and disappoint us for the future, if such status may continue.

Let us determine that we have to make our future safe and bright. We must remove or reduce all unsafe and unhealthy conditions from everywhere. If this should be the target. One thing is certain that there is no exception to safety. *The concept of safety and its strict adherence only will make our future bright and save the mankind.*

Let us determine to protect all people, working anywhere, by implementing the concept of safety through and by effective prevention and control measure.

SUMMARY:

Liver resources must be protected against the hazards of dead resources. The most important live resources is 'man' who is at the centre of all safety activities. His health is to be protected from the hazards of race for acquiring wealth and all ill effects of industrialization and accidents.

This basic need explains us the concept of safety and this concept is not new. It is age-old and universal accepted. It has many facets like diamond. It includes all branches of knowledge, which is useful to identify and prevent or control the hazards. In its wider meaning of 'environmental safety' it includes accident prevention, occupational health, hygiene and environmental protection. For this purpose, it includes all statutory and non-statutory safety measures.

It must be determined that there is no exception to safety.

E X E R C I S E

1. "Introduction to safety is incomplete without understanding the concept of safety". Explain this statement and discuss "The concept of safety as the basic philosophy of safety
2. Explain and derive the concept of safety.
3. Define 'Industrial Safety' and explain its meaning with examples.
4. **Explain the lessons of the following examples:**
    1. Glowing girls.
    2. Green-peace International Report.
    3. Dangers of pesticides.
    4. Spray-bottle in school bags.
    5. BARC repot.
    6. Down to Earth repot.
    7. Courts' orders on pollution control.
    8. Scandinavian Research report.
    9. WHO report on Air Pollution.
    10. The landing of *Pathfinder*.
    11. Atlanta Report.
    12. Ganga and Yamuna, both are polluted.
    13. Agenda Report of Central Labour Ministry.
    14. Falling of Colombia Space Shuttle.
    15. Hazards of Modern Leaving.
    16. Effects of Adulteration.
    17. Polluted Air and Water.
    18. Pesticides Poisoning.
    19. Dangers of Cold Drinks.
    20. Technology Advantages.

Reference and Recommended Reading

1. Rugved ¼_xosn½ and Yajurved ¼;tqosZn½-
2. Upanishads ¼mifu"kn½-

3. Mahabharat ¼egkHkkjr½ and Gita ¼xhrk½
4. Kautilya's Arthshashtra ¼dkSVyh;e~ vFkZ'kkL=e~½
5. Labour Policy ¼Jeuhfr½ by : D.B. Thengadi, G.S. Gokhale and M.P. Mehta, a Memorandum submitted to National Commission on Labour, by Bharatiya Mazdoor Sangh, Nagpur – 2/
6. Industrial Accident Prevention, by H.W. Heinrich, McGraw-Hill Book Co.
7. Industrial Hazard and Safety handbook, by Ralph W.King, John Magid. Butterworth.
8. Handbook of Chemical Safety, by Gujarat State Factory Inspectorate Gazetted Officers Association, Ahmedabad.
9. The Factories Act, 1948
10. Accident Prevention Manual for Industrial Operation, NSC, USA.
11. Gujarat Smachar' and other News Papers.
12. oSKkfud i}fr] izfo/kki vius foKkl] MkW-th-ls- ijht ;us Hkrjk; gslkbZZ] loksZ/; iqLrdky;] lqjr

CHAPTER – 2

Philosophy of Safety

THEME

What is stated in Chapter -1 about the Concept of Safety falls within the scope of philosophy of safety which we will see, now, in further detail.

1 WHAT IS PHILOSOPHY?

Philosophy is originally an Indian branch of knowledge. It had existence in our country before the English work 'philosophy' came into the existence.

Thousand years ago our profound Rushies and great thinkers told about rRo (element) and search for its rRoKku (knowledge), and this rRoKku is our oldest and current synonym for the English word 'philosophy'. It has its origin in Vedas, Smruties, Upnishads, Ramayana, Shrimat Bhagwat and other Purans, Mahabharat, Gita and many old and modern Indian literatures. Gita explains it as follows:

rf}f} izf.kikrsu] ifjiz'usu lso;kA
mins{;fUr rs Kkua] KkfuuLrRonf'kZu% AA

know that knowledge by leaning down, interrogating and serving to the philosophers who will teach you that knowledge.

Our concept of philosophy is a branch of knowledge searching for basic elements, origin, source, causation, effect reality and means to achieve and apply them to various fields. It includes science, which is a specific branch of knowledge having some characteristics like verifiability by experiments, definiteness, objectivity, certainty, predictability etc.

The philosophy is older and wider than the wide science, as it is in existence since centuries and has wide coverage of knowledge of all branches including that of science also. To study the nature and origin of science, its branches, utility, applications etc. is philosophy. It also studies art, sculpture, /keZ (which has no synonym in English and which does not mean religion), psychology, history of universe and its cause and effect.

Our old concept of philosophy was more concerned with /keZ] v/;kRe] search of God, universe, its elements, realities, causes and effects. As the scientific rules were invented gradually, science ¼foKku½ was separated as a special branch of philosophy.

The western concepts of philosophy are defined by Plato, Aristotle, Hegal, Bredle, Comte, Bartrand Russell, Dr. Brod, Kent, Fichte, Democratic, Marx, Burgsan etc. They have also explained the philosophy of science and the difference between the philosophy and science Their concepts are criticized and counter argued by other philosophers. Their views in brief are as follows:

Philosophy is a study of true realities and of appearances. It is the super science. It analyses and examines original or fundamental concepts of science or assumptions. It coordinates the scientific results with religions and moral experience of man. It studies the language and meanings. It visualizes or assesses the knowledge, its root, measure and limitations.

Philosophy has three original branches:

1. **Ontology searching** the root cause or fundamental element(s) in the creation of world.
2. **Cosmology** searching how this visible world is developed from the final element.
3. **Epistemology** discussing the forms, types, tests and limitations of the knowledge.

There are three conceptions about philosophy of science.

1. Its purpose is to think about the line of thinking and logic of science, and
2. Its function is to coordinate various kinds of knowledge, and
3. Its specific work is to analyse the methodology and problems of science.

Major problems of philosophy of science are the problems of reductionism, technology explanation, causation and induction.

Difference between Science and Philosophy

The science has specific subjects and divisions, it rest upon experience, observation, experiment and examinations, its rules are universal, unaltered and unchangeable. It has no two opposite statements or opinions and it does not recognize religion.

The philosophy has no specific subject, it interprets facts and findings, it searcherfor common principles lying at the root of facts, it finds generality of totality, it does not need experience or experiment, though it recognizes them, its attitude is intellectual and logical, it includes theories of opposite opinions also viz. reality and ideology, spiritualism and materialism, }Sr & v}Sr] ukfLrd & vkfLrd theistic and atheistic, free behaviour and morality etc. it recognizes the religion and always looks for the final truth.

2 PHILOSOPHY OF SAFETY

After understanding the nature of philosophy in general, let us be precise over the philosophy of safety.

2.1 Need of Safety Philosophy :

The objectives of philosophy of safety are to –

1. Think about what is safety, what is its need, where it is required, what are its types and applications etc.

2. Protect and serve the mankind, to search, suggest and apply
   (a) the safe ways of behaviour (action)
   (b) the safe working conditions and
   (c) the safe environment for the safety, health and welfare of all people.

This shows the highest importance of the subject of safety, as it has started form the age-old need of need forever. This is the superme significance of the philosophy of safety.

2.2 Nature and Subjects of Safety Philosopy:

Safety is directly connected with science, technology, engineering, health, hygiene, toxicology, psychology, management and law specific rules or principles on specific safety subjects. The philosophy of safety tries to search and coordinate the common causes and remedial measures for general as well as specific safety problems. It begins with the basic need or requirement of safety, its fundamentals, causation analysis and consequence, methods of detection of unsafe condition, unsafe action and reason and sequence of accident occurrence. It searches for the principles and methods of accident prevention and speedy control after the happening, safety devices, fittings, techniques and measures, factors impeding and approving safety, safety responsibility and roles of various agencies: terminology, theories and mysteries of accident causation, prevention and control. It studies for physical, physiological, psychological and other factors affecting and strengthening safety. It studies costs and types of accidents and their significance, type of safety management necessary and ways and means of providing and maintaining safe working conditions and human actions affecting health and safety of people and the safety of environment. It touches the origin, development and amendment of safety law and its innovation and all safety needs in the areas of industrial and environmental safety including safety at home, road, rail, water and air. Thus the field of safety philosophy is unlimited, its scope is very wide to include the entire subjects of safety from origin to the research, the latest development and form causation and behavioural analysis to the modern concept of design, testing, reliability, hazard control techonolgy, risk analysis, assessment and audit, emergency planning, public awareness and involvement programmes and all future developments.

3 SAFETY TERMINOLOGY

Like other branches of science, many words and terms are now well defined in safety science. Some terms are defined by statutes from legal point of view. Some commonly used safety terminology is given below. It is most important to understand these words as they clarify many concepts of safety philosophy, safety science and safety law. Other terms are defined in respective chapters. For terminology of MSDS, see part 7.2 of Chapter – 18. For terminology of Risk Management see Part 4.3 of Chapter – 19.

3.1 Accident:

An accident is defined in different ways

Dictionary meaning of ‘accident’ is an unexpected event or mishap. It is defined as an event that is not expected, intended or imagined. It refers the event not the result or effect.

An accident is an unplanned event that interrupts the completion of an activity and that may (or may not) cause damage to person, property or environment.

Unintentional injury is the preferred term for accidental injury in the public health community. It refers to the result of an accident.

An accident is unintended, unplanned event or its sequence caused by unsafe condition(s) or/and unsafe act(s) and may result in immediate or delayed undesirable effects.

An accident is an unplanned and uncontrolled event in which the action or reaction of an object, substance, person, or radiation results in personal injury or the probability thereof.

It is also defined as an unexpected, unintended or unforeseen event that causes injury, loss or damage.

An accident is any unplanned, sudden event, which causes or is liable to cause or is liable to cause an injury to man materials (including plant) or environment.

An accident is any occurrence that interrupts or interferes with the orderly progress of the activity which causes or likely to cause injury with or without damage to property or environment.

An accident is the result of carelessness, casualness or any fault known or unknown.

An accident is an unwanted transfer of energy beyond the threshold limits. In case of accident to a person, physiological energy loss is an accident while in other cases it may be an energy loss from material.

It is an event, which is unexpected, unavoidable, unintentional act resulting from the interaction of host (accident victim), agent (injury deliverer) and environmental factors within situations, without involve risk taking and perception of danger – *Suchman.*

An accident is an unexpected, unplanned event which has a probability of causing personal injury or property damage or both. It may result in physical harm (injury or disease) to person(s), damage to property, loss to the company, a near miss or any combination of these effects including delayed effect.

An accident is an unexpected, unplanned event in a sequence of events, that occurs through a combination of causes, it results in physical harm (injury or disease) to an individual, damage to property, equipment, building etc., a near miss, loss to the company, or any combination of these effects.

An accident is an unplanned, not necessarily injurious or damaging event that interrupts the completion of an activity. It is invariably preceded by an unsafe act or an unsa fe condition or their combination.

An industrial (occupational) accident is also defined a san undesirable event that result in a certain length of disability and stoppage of work and time loss due to the effect of a production-related dangerous factor or a combination of such factors.

An occupational accident is presently regarded as an index or a symptom of dysfunction in a system formed by a production unit, such as a factory, a workshop, a shift or a workplace.

Occupational accident is also defined as "any organic or functional injury or damage to body, limbs or health or psychic disorder due to an external, sudden or violent cause occurring during work or due to work itself and resulting in death or total or partial, permanent or temporary incapac ity for work" Fata accident or death from accident is an accident that results in one or more deaths within one year from the date of accident.

Philosophy of accident: it should be noted from above definitions of 'accident' that-

1. In accident phenomenon, which includes event and its effect, 'event' is more important then its 'event' Event or consequence may or may not be there. For example, a person getting chemical splash (exposure), struck by falling body, falling by striking against object, falling from height, getting electric shock or meeting with road accident may not get any injury or his normal activity may not be interrupted. Here event has taken place but it has not a notable effect. Even then this is an accident for the purpose of finding the 'cause' of event and remedial measures to prevent its recurrence.

2. Event may be one or more. One thing falls or may things fall one by one, only fire takes place or explosion follows the fire, events of primary and secondary explosion, collision of many vehicles, one persons die or more persons die in a sequence or due to different injuries in one accident may constitute one accident.

3. Idea of 'accident by chance' is not acceptable in safety philosophy. Each accident has its 'cause' or 'cause' that need inquiry, investigation and efforts to remove them. Considering accident as chance or fate does not help to prevent the accident and may result in another accident. Event if it is considered as chance, the 'causes' of that chance occurrence are important.

4. There may not be immediacy between event and effect. For example, pain or symptom may appear after repeated actions or few hours or days after the accident, cancer may occur after years from the exposure of a toxic substance. This delay or latency period' hides the effect for some time. However such accident of delayed effect may prove most serious and needs thought investigation and effective control measures viz. pesticide poisoning and control.

5. Duration or span of event may be short or long Span of event should be considered from its beginning to the end of the effect or consequence. Therefore when effect occurs just after the event begins, duration of event is short and when effect occurs after a long time (i.e. delayed effect) form the beginning of the event duration of the event is long. Therefore in definition of accident, immediate or delayed, both the effects are included. Chronic disease (effect) requires events of long duration.

   Legal definition of 'non fatal injury accident' or 'dangerous occurrence' makes it reportable after the duration of 48 hours from the time of accident. Thus legal definition of accident has considered 48 hours duration of event to notice any harmful effect. Accident causing death or possibility of death is to be reported immediately (Sec. 88 & 88A, the Factories Act).

   See Chapter-4 for further details about 'accident' its causation and causation and prevention and Chapters-28 & 29 for legal definitions.

3.2 Accident Consequence Analysis:

Consequence means effect or result of a specific event.

Accident Consequence Analysis is an analysis of the expected effects of an accident, independent of frequency and probability.

Mostly this is carried out after the completion of Risk Assessment to predict the consequences i.e. severity of the effects due to the assumed worst or maximum credible accident scenarios. See part 3.100.

With accident consequence analysis, the Vulnerability Analysis may be carried out of the persons, property and environment adversely affected.

Computer software is useful in carrying out consequence analysis and vulnerability analysis.

In such type of analysis, determination of following things is important –

1. Type of substance being released e.g. gas, liquid or liquid with vapour etc.
2. Type of release i.e. instantaneous, continuous, intermittent etc.
3. Leak rate or outflow volume and rate of evaporation in case of liquid pool

4. Dispersion calculation of the released mass. Parameters of atmospheric conditions are considered e.g. wind speed, weather condition (stability class) cloudiness, terrain conditions and sinking mechanism and absorption (influence of tree, houses etc. as obstruction of toxic gases.)
5. Damage distances i.e. damaging concentration or effect of fire or explosion at different distances in the direction of wind or other showing these distances and effects.
6. Severity of the effect i.e. vulnerability in terms of possible deaths, injuries, destruction of building or damage to environment. Use of probit equation.
7. Plotting of 'risk counters' on the area map of place of release and vicinity. Counters should indicate low, medium and high risk areas.

3.3 Accident Prevention :

Accident prevention is both science and art. It represents, above all other things, control i.e. the control of human performance, machine or equipment performance and physical environment.

The word 'control' connotes prevention as well as correction of unsafe conditions and actions. Prevention is the first step of control.

To control unsafe human actions, knowledge of psychology, philosophy and management are necessary. To control unsafe conditions, knowledge of engineering, health effects, industrial hygiene, ergonomics etc. are necessary.

Accident prevention requires five steps organisation, fact-finding analysis if the facts found, selection of remedy and application of the remedy. Sixth step of monitoring should be considered. It includes measurement of result, assessment i.e. comparing with legal criteria or standard, feedback and further improvement if necessary. See Chapter-4 for details.

3.4 Air Pollution:

In short it means contamination of air by harmful substances like toxic gas, dust, vapour, acid fumes, flue gases fuel gases etc. when it exceeds legal permissible limit, it is considered legally harmful.

In its broad meaning it includes detection, monitoring and chemical analysis of air pollutants, air pollution control equipment and engineering measurements and standards of industrial and automotive emissions and common air quality parameters, odours, acid rains, thermal discharge, gas and particulate emission, climate change, greenhouse effect, ozone depletion, chemical and biological aspects of air pollution, radioactive fall out radiation levels and their effects of air pollutants on soil, plants and animals.

3.5 APELL:

It means 'Awareness and Preparedness for Emergencies at Local Level'. It is a co-operative programme of the United Nations Environment Programme (UNEP), Industry and Environment Office prepared in june 1987, and was started in late 1988.

APELL's main goals are to prevent technological accidents (disasters) and, failing this, to minimize their impacts. This is achieved by assisting decision-makers and technical personnel to increase community awareness of hazardous installations and to prepare coordinated response plans involving industry, government and the local community, in case unexpected events at these installations should endanger life, property or the environment.

Thus APELL consist two parts (1) Provision of information to the community, which is called 'Community Awareness' and (2) Formulation of a plan to protect the public, which is called 'Emergency Response'. (On-site and off-site Emergency plans are legally suggested).

3.6 Care and Types of Care:

Reasonable care is that degree of care exercised by prudent man observance of his legal duties toward others.

Every person has a legal duty to exercise *due care* for the safety of others and to avoid injury to others if possible. Common carriers must exercise *great care.*

Responsible care is the safety duty towards society. Now this has developed as a systematic approach.

Responsible care is a chemical industry initiative, which started in Canada in the late in the late 1970s and is slowly gaining worldwide momentum: it is voluntary and the willing company has to demonstrate its commitment to improve all aspects of performance relating to safety, health & environment. This helps, in turn, to develop and maintain public acceptability of that industry

In India, ICMA (Indian Chemical Manufacturers' Association) has adopted six codes of management practices fro responsible care as under:

1. The Process Safety Code.
2. The Employee Health & Safety Code.
3. The Pollution prevention Code.
4. The Community Awareness & Emergency Response Code.
5. The Distribution Code, and The Product Stewardship Code.

3.7 CASH:

This means Change Agents for Safety & Health. This is a term used for Occupational Health and Safety program where different agents like noise, dust, heat stress, injures, chemical exposures, PPE, light, ventilation etc are considered as targets (.agents) for necessary change to get desired improvement at the work place.

3.8 Chemical Accident:

As defined u/r 2(a) of the Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules, 1996, it means an accident involving a fortuitous or sudden or unintended occurrence while handling any hazardous chemicals .[defined in rule 2(b)] resulting in continuous, intermittent or repeated exposure to death or injury to any person or damage to any property but does not include an accident by reason only of war or radioactivity.

3.9 Chemical Safety:

It means 'safety' from hazards of chemical. See definition of 'safety' at Sr. No. 3.80 following.

3.10 Code of Practice:

It is a document offering practical guidance on the policy, standard-setting and practice in occupational and general public safety and health for use by governments, employers and workers in order to promote safety and health at the national level and at the level of the installation. A code of practice is not necessarily a substitute for existing national legislation, regulations and safety standards.

3.11 Confined Space:

Confined space as defined in clause (o) of Part1, Schedule-19, Rule-102, Gujarat Factories Rules, means any space by reason of its construction as well &s in relation to the nature of the work carried therein and where hazards to the persons entering into working inside exist or are likely to develop during working.

Normally a confined space is enclosed from all sides except one for entering inside and coming out from the same e.g. manhole or open top. It is not a normal place for working. Inside risks include possibility of toxic gas or dust, oxygen deficiency, fire, explosion, high temperature, sudden flow or pressure, accidental starting of stirrer etc., burying (engulfment) under free flowing solid e.g. grain, cement, sugar, drowning in liquid at bottom and similar causes.

NIOSH, USA describes 'confined space' as a space which has any one of the following characteristics:

1. Limited opening for entry and exit.
2. Unfavourable natural ventilation, or
3. Not designated for continuous worker occupancy.

Confined space is also classified as that –

- has vertical or maze exit, or
- contains loose dust, fluidised materials or unstable solids.

Examples of confined spaces are - tank, pit, sump, vat, duct, gutter, tunnel, sewer, drain, trench, pipe, reaction vessel, boiler, chimney, flue, furnace, oven, ceiling voids, enclosed room/basement etc.

Proper safety work permit, work place monitoring, use of self breathing apparatus and safety belt, rescuer standing outside and holding life line are the important **safety measures.**

See Part 2.1 of Chapter 16 also.

3.12 COSHH:

It means 'Control Of Substances Hazardous to Health' Regulations 1994, published by the Health and Safety Executive (HSE), UK. It is a guideline, not compulsory but helpful. Its compliance requires -

1. Assessing the risks to health arising from the work.
2. Deciding what precautions are needed.
3. Preventing or controlling exposures.
4. Ensuring that control measures are used and maintained.
5. Monitoring exposures of workers to hazardous substances and carrying out appropriate health surveillance, and
6. Ensuring that employees are properly informed, trained and supervised.

3.13 Damage Control:

It is directly concerned with the protection of machinery, materials and manufactured goods assets from accidental loss within the factory. Indirectly it is concerned with money asset and manpower asset.

Damage can be defined as severity of injury or the physical, functional or monetary loss that could result if control of a hazard is lost.

3.14 Danger:

It expresses degree of exposure to a hazard. By taking suitable precautions, the danger is reduced. Machine guarding or safety device reduces the danger of a particular hazard.

3.15 Dangerous Occurrences:

Dangerous occurrences are mentioned u/s 88-A, of the Factories Act 1948 and u/r 103 of the Gujarat Factories Rules 1963. They' include:

1. Bursting of a steam plant under pressure.
2. Collapse or failure of lifting appliances or overturning of a crane.
3. Fire, explosion, escape of molten metal, hot liquor, gas etc.
4. Explosion of a pressure vessel.
5. Collapse or subsidence of a structure. For Dangerous Chemical Reaction see Part 3.39.

3.16 Disaster:

Disaster is a catastrophic situation in which the day-to-day patterns of life are, in many instances, suddenly disrupted and people are plunged into helplessness and suffering and as a result need protection, clothing, shelter, medical and social care and other necessities of life, such as-

1. Disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm, surges, cyclones, tropical storms, floods, landslides, forest fires .and massive insect infestation. Also in this group, violent draught, which will cause a creeping disaster leading to famine, disease and death must be included.

2. Second group includes disastrous events occasioned by man, or by man's impact upon the environment, such as armed conflict, industrial accidents, factory fires, explosions and escape of toxic gases or chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents, aircraft crashes, collisions of vehicles carrying inflammable liquids, oil spills at sea, and dam failures.

3.17 Disaster Management Plan (DMP):

This is the requirement of Government Dept. (MoEF, GPCB, Factory Inspectorate, Collectorate etc.) under various Acts and Rules.

It includes On-site emergency plan and Off-site emergency plan. Its key elements are

1. **Basis of the plan or risk assessment.** Hazards and emergency situations are determined with their possible effects. Typical scenarios and consequences are outlined for the purpose of offsite emergency plan (see part 3.2).

2. **Accident prevention procedures and control measures.** Organisational set-up and division of responsibility. It includes listing of control measures provided in the factory and to be managed from outside if not available in the factory. Help from outside agencies.

3. **Emergency response procedures.** It includes emergency control centre, communication system and description of roles to be played by plant people and outside agencies.

4. **Recovery procedures.** It includes safe shutdown or flow restriction procedure, evacuation and restoring of normal condition.

See Part - 7 of Chapter - 19 for details.

3.18 Ecology:

It includes interaction between microbes, plants and animals and their environment, which are primarily affected by climate, water resources, soil and man, ecosystem studies, ecology of grasslands, woodlands and wetlands, arid zones and high altitude environments, coastal ecosystem, mangroves, aquatic ecosystem, fresh waiter, river basins, brackish water, marine, estuarine and soil ecology.

3.19 Emergency:

Emergency could be defined as any situation, which presents a threat to safety of person or/and property. It may require outside help also.

As defined in clause 2(j) of Schedule 19 of Chemical Works u/r 102 of the Gujarat Factories Rules (GFR), emergency means a situation leading to a circumstance or set of circumstances in which there is a danger to the life or health of persons or which could result in big fire or explosion or pollution to the work and outside environment, affecting the workers or neighbourhood in a serious manner, demanding immediate action.

It is also defined as, 'a dynamic incident in which there is continuing potential for major injury, ill health, damage to property, to the process or to the environment.'

3.20 Emergency Plan:

Emergency plan is a formal written plan, which on the basis of identified potential hazards at the installation together with their consequences, describes how such hazards and their consequences should be handled either on-site or off-site. See DMP at Sr. No. 3.17.

See Part 7 of Chapter - 19 for details.

3.21 Emergency Services:

Emergency services mean external bodies which are available to handle major accidents and their consequences both on-site and off-site, e.g. fire authorities, police, health services etc.

3.22 Environment:

As defined u/s 2(a) of the Environment (Protection) Act, 1986, it includes water, air, land and the inter relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organisms and property.

3.23 Environmental Management:

In its broad meaning it includes Government policies, planning, programmes, regulations and legislations, international agreements, environmental impact assessments(EIA), environmental education, environmental law and legal actions, sustainable development, siting of industries, clean technologies, eco-development and ecosystem management, managerial aspects of forestry, biosphere, conservation, waste and wildlife.

3.24 Environment Management Plan (EMP):

After identification and assessment of adverse impacts on environment due to proposed activity of a new plant or expansion of existing plant and after preparation of Environment Impact Assessment (EIA) document. Environment Management Plan (EMP) becomes necessary.

The EMP describes general good practice measures and site-specific measures to mitigate potential impacts due to the proposed industrial activities. The EMP provides mechanism to address potential adverse impacts, to instruct contractors and to introduce standards of good practice to be adopted for all project works.

For each stage of the programme, the EMP suggests effective mitigation of every potential biophysical and socio-economic impact identified in the EIA. It presents following information:

1. A list of mitigation measures.
2. Parameters to be monitored to ensure effective implementation of the action.
3. Time schedule to implement actions to ensure that the objectives are fully met.

3.25 Environmental Pollutant:

Defined u/s 2(b) of the Environment (Protection) Act 1986, it means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment.

Environmental Pollution means the presence of environmental pollutant in environment.

3.26 Error:

Errors are of different types, viz. human error, design error; planning, production, operation and maintenance error etc.

Human error can be defined as a human's action, which differs from or is inconsistent with prescribed or established behaviours or procedures. It may be of two types: predictable or random.

Predictable error occurs under similar conditions and can be foreseen because it has occurred more than once.

Random error is non-predictable and unique in nature. For example, all of a sudden a fly or insect enters in eye due to which a worker may throw away a tool or lose his balance and cause error. But if flies become common phenomena i.e. predictable, the error becomes predictable one and remedial measures are required.

Human error takes place due to omission (failure to perform a required function) or commission (performing a function not required), failure to recognise hazard, poor response, poor timing, wrong decision, sudden disturbance etc.

3.27 Evacuation:

It means to move all people from a threatened area to a safer area. It is required as a function of Onsite or Offsite Emergency Plan.

3.28 Fire Prevention and Control:

It is a special aspect of damage control. It protects machinery, materials, manufactured goods, money assets and manpower from damage due to fire.

See Chapter - 13 for details. -

3.29 Flash fire and Jet fire:

A flash fire is the non-explosive combustion of a vapour cloud resulting from a release of flammable material into the open and which after mixing with air, ignites. A flash fire results from the ignition of a released flammable cloud in which there is essentially no increase in combustion rate. The ignition source could be electric spark, a hot surface and friction between moving parts of a machine or an open fire.

Thus flash fire means a release of flammable gas under unconfined condition in the presence of air and ignition source. Dispersion process occurs between LEL and UEL with no increase in combustion rate.

A jet fire occurs when flammable gas releases from the pipeline (or hole) and the released gas ignites immediately. Damage distance depends on the operating pressure and the diameter of the hole or opening flow rate.

3.30 Foresee-ability:

A man may be held liable for actions that result in injury or damage only when he was able to foresee dangers and risks that could be reasonably anticipated.

3.31 Forestry:

It includes afforestation, including social forestry and energy plantation, deforestation, ecology and management of forests, influence of forest on the physical environment, protection of forests, soil conservation and erosion of forests, watershed / catchments management, endangered and threatened plant species.

3.32 Handling of a Substance:

As defined u/s 2(d) of the Environment (Protection) Act, it means the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, offering for sale, transfer or the like of such substance.

3.33 Harmful Element:

It means a substance, which in contact with the human body is likely to cause, during employment and long after, identifiable by modern methods, injuries and diseases or likely damage to the health of the present and future generations. Harmful elements may be injurious, toxic, corrosive or irritating.

3.34 Hazards:

Hazard means existing unsafe condition or action or situation or event or their combination which has potential to cause accident. Thus hazard can become a cause of accident or risk and it can exist without accident or risk. When due to hazard, accident happens, it is converted into accident. If hazard still exists, accident may happen again, viz. flammable atmosphere.

The causes of accidents generally remain latent for some time before anaccident occurs. These latent or potential causes are hazards. Hazards are sometimes referred to synonymously with accident causes, but there is a clear distinction that a. hazard can exist without an accident whereas an accident cause without an accident is an absurdity. Hazard recognition, diagnosis and elimination are essential to any successful safety programme.

Hazard is an inherent property of a substance, agent, a source of energy or situation having the potential of causing undesirable consequences.

Hazard means an intrinsic capacity associated with an agent or process capable of causing harm.

Hazard is defined as, 'any event with the potential to cause harm, ill health, injury, damage to property, plant, products or the environment, production losses or increased liabilities.'

Hazard is a condition with the potential of causing injury to personnel, damage to equipment or structures, loss of material, or lessening of the ability to perform a prescribed function. When hazard is present, the possibility exists of these adverse effects occurring.

Chemical Hazard is a hazard due to chemical (including its property, storage, process, handling, effect etc.) and it is realised by fire, explosion, toxicity, corrosion, radiation etc.

Major Hazard is a large-scale chemical hazard, especially one, which may be realised through an acute even.

For Major Accident Hazard (MAH) see part 3.55 following.

Occupational hazards are the hazards arising in course of and out of occupation or employment. They include physical, chemical, biological, mechanical, electrical, psychological and all occupational health hazards, diseases and poisoning.

Rapid ranking method is a means of classifying the hazards of separate elements of plant within an industrial complex, to enable areas for priority attention to be quickly established.

3.35 Hazards Analysis:

In simple term, hazard analysis means classification of hazards, eg. chemical hazards, mechanical hazards, electrical hazards, fall hazards, day and night wise hazards etc. in this way it is qualitative analysis.

Hazard Analysis is (i) Analysis of mechanism of hazard occurrence and (ii) Analysis of terminal consequences of hazards which may include number of injury, fatality, property damage and other loses. In this way it is quantitative analysis. Its study is known as HAZAN (Hazard Analysis). It means identification of undesired events, which lead to the materialization of a hazard, analysis of the mechanism by which such .undesired events could occur, and estimation of the extent, magnitude and likelihood of any harmful effects or consequences.

Preliminary Hazard Analysis (PHA) is a procedure for identifying hazards early in the design phase of project before the final design has been established. Its purpose is to identify opportunities for design modifications, which would reduce or eliminate hazards, mitigate the consequences of accidents or both.

HAZAN (Hazard analysis) is generally undertaken at the preliminary stage of determining the location, basic design principles and operational parameters to establish the adequacy of basic safety of design, operation and environmental control. It may be followed by an updated analysis to establish final risk levels. HAZAN exercise has to be undertaken by a professional team with expertise in failure mode and effect analysis, fault tree analysis, simulation and modelling, event tree and consequence analyses.

3.36 Hazard Assessment and Survey:

Hazard assessment is an evaluation of the results of a hazard analysis including judgments as to their acceptability and, as a guide, comparison with relevant codes, standards, laws and policies.

Hazard survey means the total efforts involved in an assessment of the hazards from installations and their means of control.

3.37 Hazard Identification:

It is an identification of sources of hazards and their causes. It is qualitative. Its study is known as HAZOP study.

Many methods and techniques are available to identify hazards. See Chapter -19.

In simple term, it means listing of unsafe conditions, actions, situation etc.

Hazard identification is the first and important step. If hazards are identified and removed, risks are prevented. If risks are prevented, accidents are prevented. If accidents are prevented, injuries and losses are prevented and that is the object of safety.

3.38 Hazardous chemical:

Hazardous chemical is defined u/s 2(e) of the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 as a listed chemical in Schedule 1, 2 and 3 therein. The same term is also similarly defined u/r 2(b) of the Chemical Accidents (Emergency Planning Preparedness and Response) Rules 1996 and u/r 68J(1)(a) of the Gujarat Factories Rules, 1963.

When threshold quantity of hazardous chemical listed in Sch. 2 or 3 exceeds in a plant it is identified or classified as a Major Accident Hazard (MAH) installation. See Part 3.55 also.

3.39 Hazardous Substance, Process and Reaction:

Hazardous substance is defined u/s 2(e) of the Environment (Protection) Act 1986, as a substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plants, micro-organism, property or the environment.

It is an element, compound, mixture or preparation, which by virtue of chemical, physical or (eco) toxicological properties constitutes a hazard.

Toxic Substances as defined in clause (i), Schedule 19 on Chemical Works u/r 102 of the Gujarat Factories Rules, mean those substances which cause fatality or serious health effect and which exceed their TLV specified in the 2nd Schedule of the Factories Act (See Table 15 in Chapter-32).

Hazardous Process as defined u/s 2(cb) of the Factories Act, means any process or activity in relation to an industry specified in the First Schedule, where, unless special care is taken, raw materials used therein or the intermediate or finished products, bye-products, wastes or effluents thereof would -

1. Cause material impairment to the health of the persons engaged in or connected therewith, or
2. Result in the pollution of the general environment.

Dangerous Chemical Reactions as defined in clause (k) of Schedule 19 on Chemical Works u/r 102 of the Gujarat Factories Rules, mean high speed reactions, run-away reactions, delayed reactions etc. and are characterised by evolution of large quantities of heat, intense release of toxic or flammable gases or vapours, sudden pressure build-up etc.

Unit processes and operations mentioned in Sch. 4 u/r 68J of the Gujarat Factories Rules, when involve or likely to involve 'hazardous chemical' as defined in Part 3.38 above, activity in that installation or isolated storage is called **hazardous industrial activity**.

3.40 HAZOP:

Hazop (Hazard & operability) study is carried out by application of guidewords to identify all possible deviations from design intent having undesirable effects on safety or operability, with the aim of identifying potential hazards.

Hazop study is normally undertaken at an advanced stage of project implementation when the design criteria are well established. The study can be used for both new and working plants. They have to be carried out by multidisciplinary teams of experienced technical personnel having detailed knowledge of both the design ,and operation of a plant.

A preliminary Hazop study is intended to review the general parameters of materials processed, unit operations and layout of individual units and plant sub-units. A detailed Hazop study is required after the finalization of the designs to identify the potentially hazardous situations and to arrive at agreeable options to rectify design deviations and anomalies.

See Part 4.6 of Chapter -19 for details.

3.41 Health and Toxicology:

In its broad meaning, it includes toxicology of pesticides, heavy metals, industrial and agricultural chemicals and other environmental contaminants, effects of toxic materials, fertilizers, pesticides etc. on human, animals, plants and soil, contaminants, measurement and methodology, occupational and public health, use .and transportation of hazardous materials, industrial accidents and safety.

3.42 HSMD:

The Hazardous Substances Management Division (HSMD) is the nodal point within the Ministry for Management of Chemical Emergencies and Hazardous substances. The main objective of the Division is to promote safe management and use of hazardous substances including hazardous chemicals and hazardous wastes, in order to avoid damage, to health and environment. The Division is also the nodal point for the following three International Conventions.

1. The Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal.
2. The Rotterdam Convention on the Prior Informed Consent (PIC) procedure for certain hazardous chemicals and pesticides in International Trade.
3. The Stockholm Convention on Persistent Organic Pollutants (POPs).

The activities of the division are carried out under three main thrust areas, viz.. Chemical Safety, Hazardous Waste Management and Solid Waste Management.

3.43 Incident:

An incident is any observable human activity sufficiently complete in itself to permit references and predictions to be made about the persons performing the act viz. cleaning an unguarded machine, failing to wear PPE, using compressed air on body, raising pressure or temperature unnecessarily.

It may result in accident or a near miss.

Incident for accident is defined as, 'an unplanned event or series of events that has or could have, caused injury to people and / or damage to assets and / or damage to the environment and / or loss of reputation.

3.44 Industrial Health & Hygiene:

This is connected with the protection of the manpower asset from industrial illnesses, diseases and other long-term accidental effects caused by industrial environment on human bodies. Indirectly it protects money asset.

Specific areas for consideration include: noise, dusts, gases, vapours, corrosives, toxic materials, ventilation, heating, lighting, humidity, environmental monitoring, biological monitoring, health checks, general and personal hygiene, counselling, health education, employee screening and placement and medical antidotes.

Occupational Hygiene Practice includes:

(a) Anticipation or Identification and Recognition of the possible health hazards in the work environment.

(b)' Evaluation of hazards, i.e. the process of assessing exposure (comparing with standard) and reaching conclusion as to the level of risk to human health.

(c) Prevention and control of hazards, which is the process of developing and implementing strategies to eliminate/ reduce to acceptable levels, the occurrence of harmful agents and factors in the workplace. It will also account for environmental protection.

See Chapter -24 for details.

3.45 Industrial Hygiene Audit:

Its aim is to examine industrial hygiene practices with a view to establish their effectiveness in preventing occupational illness and their conformance with standards and regulations. Audit report should indicate whether key industrial hygiene programme elements (not necessarily degree of compliance) are present or absent. The presence of a particular element merely indicates that the organisation is capable of moving towards desirable preventing goals. Audit worksheets should include data gathering format and major agents (heat, light, noise, radiation, contaminants etc.) review sheets. Industrial hygiene policy, laboratory facility, trained manpower; communication, structure etc. should also be reviewed.

3.46 Injury:

Injury (occupational) means an injury that result in death, loss of consciousness and administration of medical treatment, temporary assignment to other duties and transfer to another job, or inability to perform all duties on any day after the injury.

Injury is considered to include occupational disease and work-connected disability. **Work injury** is defined as an injury suffered by a person, which arises out of and in the course of his employment. It is an external damage to human body; disturbance or dysfunction resulted from an accident. By cause it may be mechanical, thermal, chemical, radiated or combined.

Injury is physical harm or damage to the body resulting from an exchange of (usually acute, mechanical, chemical, thermal or other environmental) energy that exceeds the body's tolerance.

Disabling injury is an injury causing death, permanent disability, or any degree of temporary total disability beyond the day of the injury (Accident Facts, 1997, NSC, USA).

Source of injury is the principal object such as tool, machine, chemical vessel or equipment involved in the accident and is usually the object inflicting injury or property damage. Also called agency or agent.

Property damage accident is an accident, which results in property damage, but in which no person is injured.

Non-fatal injury accident is an accident in which at least one person is injured, and no injury results in death.

See Chapter -4 for further discussion.

3.47 In-place (plant) Protection:

It means to direct people to quickly go inside a building and remain inside until the danger passes. It is preferred when evacuation is not possible or more risky. It is not safe if the vapours are explosive. People inside should keep doors, windows and ventilating system closed to stop ingress of toxic gases.

3.48 Isolation:

It means to isolate hazard area and to deny entry to keep people away from the area if they have not to play any emergency response role. It is the first step for any protective action that follows.

Isolation valve means a stop valve.

3.49 ISRS:

It means International Safety Rating System. Safety rating certificate is awarded by DNV to the hazardous plants. The system includes 20 safety elements, which are audited and based on the audit, safety rating number is awarded. The system provides scope for further improvement in safety areas to get higher rating number in the next audit.

3.50 Labour Protection:

It is defined as a system of legal acts and relevant socio-economic, technological and organisational measures ensuring safety and health, accident prevention, industrial hygiene and fitness to work.

3.51 Liability:

It means an obligation to rectify or recompense any in)ury or damage for which the liable person has been held responsible.

3.52 Loss Control:

In safety philosophy the word 'loss' has many meanings.

Loss includes injury, illness, disease or death to a person.

Loss includes damage to property, equipment, material, cost of replacement or damage to environment.

Loss also occurs in terms of time, money, material, production, sales etc.

Loss of time occurs in filling of accident forms and their reporting, record keeping, investigation of causes, searching for controls, travelling for medical and legal help, hospitalisation, Govt. offices, rehabilitation and restoration of public image.

Accident may cause any type of loss. Such losses are considered in counting the costs of accident.

Loss control is defined as a management system designed to reduce or eliminate all aspects of accidental losses that lead to wastage of company assets. In this context the company assets involved are manpower, materials, machinery, methods, manufactured goods and money. Thus a system of loss control is designed to improve the overall profitability of a company by reducing both the economic and social costs associated with loss producing activities. Legal, humanitarian (social) and economic aspects are included herein. .

Total Loss Control involves reporting to control centres all property damage accidents and injury causing accidents, supplemented by spot checks and safety audits.

3.53 Loss Prevention:

It may be defined as the application of engineering techniques in order to prevent or reduce the probability of occurrence of accidents that result in personal injury, damage to property, production, equipment, building etc. and those accidents having no end result i.e. the near miss accident. Prevention is an earlier part of control. Therefore it is better than subsequent cure. When fire, security, health, hygiene, pollution control, product liability and business interruption control are added to loss preventio n', it is called loss control'.

3.54 Major Accident:

As defined by Rule 2(j) of the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989, it means an incident involving loss of life inside or outside the installation or ten or more injuries inside and/or one or more injuries outside or release of toxic chemicals or explosion or fire or spillage of hazardous chemicals resulting in on-site or off-site emergencies or damage to equipment leading to stoppage of process or adverse effects to the environment.

Major Chemical Accident is defined u/r 2(f) of the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 by the words stated in above para but also including transportation.

3.55 Major Accident Hazard (MAH) Installation:

As defined u/r 2(g) of the Chemical Accidents (EPPR) Rules, 1996, it means isolated storage and industrial activity [u/r 2(c)] at a site handling (including transport through carrier or pipeline) of hazardous chemicals [defined u/r 2(b)] *equal to or in excess of the threshold quantities* specified in Schedules 2 and 3.

It is also similarly defined u/r 2 (ja) of the Manufacture, Storage and Impact of Hazardous Chemicals Rules, 1989.

Different rules (Safety Provisions) are applicable to such factories, installations or sites depending on "Threshold quantity" of hazardous chemicals listed in Schedule 1, 2, and 3, or processes mentioned in Schedule 4.

See Part 6 of Chapter - 19 for details.

3.56 Major Emergency:

Major emergency occurring at a work is one that may affect several departments within it and/or may cause serious injuries, loss of life, extensive damage to property or serious disruption outside the works. It will require the use of outside resources (off-site emergency plan) to handle it effectively.

Usually it is the result of a malfunction of the normal operating procedures. It may also be precipitated by the intervention of an outside agency, such as a severe electrical storm, flooding, crushed aircraft or deliberate acts of arson or sabotage.

Emergency due to operating conditions (uncontrolled reaction, small fire, small gas leak, spill, failure 'of power, water, air, steam, cooling media, scrubbing media etc.) and which plant personnel alone can handle locally (without outside help) is not considered as major emergency. Operating instructions in the Safety Manual should cover this area, though the on-site emergency plan will also be helpful.

3.57 Mistake:

Mistake, in the sense of safety, can be defined as an act of wrong opinion, judgement about a thing or situation which results in hazard or harm to a person, property or environment. It means to have wrong, perception about danger or to understand it wrongly so that it may cause hazard.

Like error, as explained earlier, it is an act of omission or commission resulting in hazard or hazardous situation.

Mistakes may be committed by men or machines and can be classified as personal mistake, mechanical mistake, technical mistake, historical mistake etc. It may be small or big. A gross mistake is called blunder.

Examples of mistake are wrong judgement of the speed of a vehicle, falling body or a moving machine, to perceive blue as black, to press 'start' button instead of 'stop' button, to press clutch or accelerator instead of brake etc.

Difference between 'error' and 'mistake' is thin and may be understood interchangeably.

3.58 NHWIS:

National Hazardous Waste Information System (NHWIS) is online Web based hazardous waste information system which gives the status of hazardous waste management in India. The database will be regularly updated by all State Pollution Control Boards on web and this will ensure updated status at all times. The NHWIS project has been developed by Environment and Forest Informatics Division of NIC in 'close consultation with Hazardous Substance Management Division (HSMD) of the Ministry of Environment and Forests. It gives

1. Records of Management of Hazardous Waste by Generating Units.
2. Status of compliance to the environment regulation.
3. Data on available disposal option.
4. Queries / Reports on hazardous waste management for authority and general public.

3.59 Nature and Natural Resources Conservation:

In its broad meaning, it includes all aspects of conservation of the flora, fauna, genetic resources, water, soil and eco-system.

3.60 Near miss:

It means any unplanned, sudden event that could have caused injury to man, materials (plant) or environment or could have involved a loss of containment possibly giving rise to adverse effect but not resulted in such accident.

If near miss is detected and prevented, possible accident due to that near miss can be avoided or prevented. If causes of near miss are not removed, they can result in accident. Therefore importance to identify and control near miss is more than that of controlling accident.

3.61 Negligence:

It means failure to exercise a reasonable amount of care or to carry out a legal duty so that injury or property damage occurs.

3.62 Noise Pollution:

In its broad meaning, it includes noise levels and their effects from domestic, construction, urban, industrial, transportation and other sources, acoustic measuring and instruments, noise surveys and standards.

3.63 Occupational Disease:

Occupational disease is impairment to health, illness, poisoning or disease caused to a person by exposure to any substance or process of the occupation. It may arise out of or in course of his employment.

Occupational Disease is also defined as a disease caused by environmental factors, the exposure to which is peculiar to a particular process, trade or occupation, and to which an employee is not ordinarily subjected or exposed outside of or away from such employment.

Occupational diseases are many and listed by the Factories Act, W.C. Act and ESI Act.

See Part 4 of Chapter-24 and Part 5 & 7 of Chapter-29 for details.

3.64 Occupational Environment:

It is the sum of external conditions and influences which prevail in the place of work and which have a bearing on tile health of the working population. It includes three types of interaction - Man and physical, chemical and biological agents; Man and machine or equipment, and Man and man.

3.65 Occupational Health:

It includes all aspects of a worker's health and his/her relationship with the environment.

Basic objectives of a good occupational health programme are:

1. To protect workers against health hazards in their work environment.

2. To facilitate their placement and ensure their suitability according to their physical and mental capacities and emotional make-up in work that they can perform with acceptable norms and without endangering self or the fellow workers.

3. To assure adequate medical care (including madical examinations and health records) and rehabilitation of the occupationally injured.

4. To encourage personal health maintenance.

See Part 4 of Chapter - 24 for details.

3.66 Occupational hygiene:

Occupational hygiene is a modern specialisation concerned with assessing and controlling hazards from atmospheric contamination, skin or body absorption, radiation, noise etc.

Occupational or Industrial Hygienist - Serves as the analytical preventive engineering arm of occupational medicine by applying specialised knowledge to the recognition, evaluation and control of health hazards in the work environment.

See Part I of Chapter-24 for details.

3.67 Occupational Poisoning:

Occupational poisoning is a partial case of occupational disease. Continuous or long time exposure to relatively small amounts of noxious or poisonous substances is conductive to a **chronic poisoning,** e.g. lead or mercury poisoning, lung diseases etc. Occupational poisoning is called the acute **poisoning or intoxication** if caused by penetration into the body of a noxious substance, or immediate local effects e.g. acid burn, fire or hot burn, sun burn, cold burn, gas inhalation etc.

3.68 Off-site emergency plan:

It deals with measures to prevent and control emergencies affecting **public** and the environment outside the factory premises. The manufacturer should provide the necessary information on the nature, extent and likely effects of such incidents to the Government authorities that make and operate this plan.

Schedule-12 of the MSIHC Rules, 1996 specifies 13 items. See Part 7.4 of Chapter-19 for details.

3.69 On-site emergency plan:

It deals with measures to prevent and control emergencies affecting workers and others **within the factory** and not affecting outside public or environment. It is controlled mostly by the plant personnel, resources and equipment. Factory management makes and operates this plan.

Schedule-11 of the MSIHC Rules, 1996 specifies 13 items. See Part 7.3 of Chapter-19 for details.

3.70 Oversight:

Oversight means overlooking of something, error or supervision. When there are more switches side by side and looking identical, an operator may operate a wrong switch by oversight. While counting many things, by oversight, someone may make mistake. Thus oversight denotes a state of mind by which error or mistake is possible due to lack of concentration or attention. Result of oversight is mistake or error. Oversight leads to unsafe action and that may result in accident.

The words - error, mistake and oversight - have thin difference, all leading to the causation of hazard or accident and concern with the state of mind or human behaviour.

3.71 Pollution:

In all its aspects it is concerned not only with the environment within the factory but also the immediate environment outside the factory. Control of air, land and water pollution protects the manpower asset directly and the money asset indirectly. Special attention should also be paid to noise and vibration as pollutant.

See Part 10.5 of Chapter-28 for statutory definitions of pollution, pollutant, environment etc.

3.72 Practicable:

In legal terminology, following three terms are used:

"So far as is practicable"- This means if something is practicable it should be done. It is not practicable to take precautions against any hazard which is unknown. But once the hazard is known, it becomes practicable to take necessary precautions against it.

"So far as is reasonably practicable"- This can be a defence by an accused person that precautionary action was not reasonably practicable by him. However he has to prove this. Ultimately the Court will decide depending on facts, evidences and balance between the cost and risk in assessing it.

"Best practicable means" - This indicates a duty to comply with by taking the best measures available in the light of current knowledge and according to means and resources. This duty lies between **so far as is practicable and so far as is reasonably practicable.**

The standard of practicability depends on current knowledge and invention.

The burden of proof that something was not practicable or not reasonably practicable lies on the accused. Inconvenience and expense cannot be used as a defence.

3.73 Probability:

It means the likelihood, chance or frequency that a considered (predetermined) occurrence may take place.

Probability includes possible frequency of hazard occurrence or possible frequency of effects due to any particular hazard.

Probability and severity (effect or consequence) are two ingredients of a risk. $R = P \times S$

3.74 Product Liability:

It extends the protection to all consumers of the company's products and is primarily concerned with the protection of money asset. Attention should also be paid to a product safety strategy.

3.75 Risks:

Risk is the combination of a probability of occurrence and its severity of consequence. Thus $R = P \times S$.

Risk is the likelihood of a specific undesired event occurring within a specified period or under specified circumstances. It may be either a frequency i.e. number of events per unit time or a probability depending on circumstances.

As per example risk of death for a man aged 30 is 1×10^{-3} per annum (i.e. during a year, out of 1000 such men, one may die) and that for a man aged 60 is 1×10^{-2} per annum (i.e. during a year, out of 100 such men, one may die).

Risk is an expression of possible loss over a specific period or number of operational cycles. It may be indicated by the probability of an accident times, the damage in rupees, lives or operating units.

Risk is expressed for uncertain eventualities and it may be classed as speculative or pure. Pure risk can only result in a loss to company, whereas speculative risk may result in either gain or loss. Risk, uncertainty, probability and chance are the words, which frequently recur and most familiar to insurance people. Risk and uncertainty are ingredients of life and we are constantly talking risks merely to stay alive. '

Individual Risk is the frequency at which an individual may be expected to sustain a given level of harm from the realisation of specific hazards.

Societal Risk is the relationship between frequency of hazardous event and the number of people suffering a specific level of harm (level of concern like LOG, IDLH, LD_{50}, LC_{50}, etc.) in a given population from the realisation of that event (specific hazard). It is a measure of the chances of a number of people being affected by a single event or set of events and is often expressed by f/n curves (frequency vs. no. of people affected).

See Part 4.1 of Chpater 19.

3.76 Risk Analysis:

It means to find out probability of a hazard occurring and then an estimation of its consequence or effect and its severity. It is quantitative.

For example, estimation of probability or frequency of possible explosion and its effect on persons and property in terms of deaths, injuries, house breakages etc. is called risk analysis.

See Part 4.3 of Chapter-19.

3.77 Risk Assessment:

It is the quantitative evaluation of the likelihood of undesired events and their consequences being caused together and a value judgement concerning the significance of the results after comparing with set, legal or accepted values or standards.

It is a judgement of significance or acceptability of risk identified by risk analysis and comparing against social, political or legal criteria, e.g. comparison of measured or calculated risk with the permissible safe limits and judgement regarding safety (whether the risk level is within or exceeding the safety limit) gives risk assessment.

Though Hazard identification is a part of Risk Assessment, term HIRA ie Hazard Identification and Risk Assessment is also used by some companies.

Objective of risk assessment are :

1. Identification of vulnerable zones (losses of persons and property) of the premises.
2. Estimation of hazard distances for the maximum credible accident (MCA) scenarios.
3. Suggestions for risk mitigation measures an delineation of approach to disaster management plan (DMP).

See Part 4.3 of Chapter-19.

3.78 Risk Counter:

Risk counter is an iso-risk line on the map which a hypothetical individual staying there unprotected and for 24 hours per day would be subjected to a defined probability of fatal harm due to exposure to hazards induced by the industrial activity. This risk indicator is most frequently used to quantify the off-site risk to the public and is expressed on a per year basis.

Risk Counters are calculated by determining the consequences from a number of scenarios. By adapting certain criteria for death from toxic substances, radiation heat load from fire and explosion over pressure, effect and damage distances can be determined.

Risk transects are like risk counters, but are used for the risk from transportation by road, rail, pipeline etc.

Risk counters or 'foot prints' are plotted on the map of the premises and its vicinity (area) to see the effect of damage distances reaching to the public or surrounding environment. On each periphery of a counter, risk level should be mentioned. Counters may indicate risk zones like low, medium, high, highest etc.

3.79 Risk Management:

It may be defined as the organisational set-up for prevention or minimisation of the adverse elects of risks within a company, via the identification, evaluation and control of such risks by finding and applying remedial measures.

It is decision-making and establishing ownership of actions and monitoring to contain within limits of criteria.

Risk Management includes following Steps

1. Hazard Identification
2. Hazard Analysis
3. Hazard Assessment
4. Risk Analysis and
5. Risk Assessment.

It includes management for safety (injury prevention), damage control, loss prevention and loss control. .

See Part 4.3 of Chapter-19 for details.

3.80 Safety:

In general terms, safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage. In an .industrial context, it means the minimization of contact between human and hazard and is predominantly concerned with the prevention of physical harm (injury) to persons or/ and property. Its concept is explained in detail in Chapter-1.

Industrial safety is that condition of enterprise operations in which, by controlling hazards and risks, accident free production is achieved.

Safety is defined as a positive, organized activity or program based on knowledge of the reaction between man and his working environment, which aids business enterprise by minimizing death, losses caused by injuries, health impairment, fires, explosion and other occupational accidents.

Safety is opposite (antonym) of danger. Freedom from hazards represents absolute safety, but this is an ideal, which is seldom realised. Safety is rather a matter of protection from hazards.

Safety is a situation with acceptable risks. Thus safety mean's to bring or keep the hazard level, below permissible safe level. It includes safety, health and environment (SHE or HSE) protection including protection of property.

Operational safety concept is a strategy for process control, incorporating a hierarchy of monitoring and controlling process parameters and of protective action to be taken.

3.81 Safety Audit:

It is a critical examination of all or part, of a total operating system with relevance to safety and to suggest improvements and up gradation.

A safety audit is intended to measure the effectiveness of a company's safety programs in every respect. The objectives should be clearly defined such as-'

1. To carry out a systematic and critical appraisal of all potential hazards involving personnel, plant, services and methods of operation.

2. To ensure that the occupational health and safety standards fully satisfy the legal requirements and those of the company's written safety policies, objectives and programs.

The word 'safety audit' is also used for 'safety inspection' intended for

1. Identification of possible loss situations.
2. Measurement of the potential losses associated with these risks.
3. Selection of methods to minimize the losses.
4. Implementation of the selected methods within the company and
5. Monitoring of the result and suggesting further improvement based on review.

See Part 6.8 of Chapter-19 for details. See IS: 14489 also.

3.82 Safety Manager:

Generally connotes a person responsible for a safety organization and its activities. This person is concerned with the conduct of the safety programs at the plant(s) for which he is responsible. He may have under his immediate supervision, one or more safety engineers or officers, an industrial hygienist, industrial psychologist, risk manager and other employees knowledgeable in safety.

Risk Manager is responsible for the function of a safety manager and also for the insurance programs and other activities to minimize risks and accidental losses.

See Chapter -6 for details.

3.83 Safety Management System:

Safety Management System is defined as collectively those elements in the operator's management system which ,ensure that all loss exposures inherent in the operation have been systematically identified and risk assessed and that arrangements are in place to control the risks in these loss exposures to a level as low as reasonably practicable (ALARP) and to minimize the consequences of any failure of tile control system should, the need arise, and that the information, training, auditing and improvement processes are in place.

3.84 Safety Premises:

It is the duty of an owner or user of land to keep his premises in a condition that is reasonably safe for those lawfully there, e.g. duty of an owner of cinema or auditorium.

3.85 Safety Report:

It is the written presentation of the technical, management and operational information covering the hazards of a major accident hazard (MAH) installation and their control in support of a justification for the safety of the installation.

Schedule -8 u/r 68-J of the Gujarat Factories Rules or u/r 10(1) of the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 prescribes such report with 10 items.

See Part 6.8 of Chapter-19 for details.

3.86 Safety Committee:

It is prescribed u/s 41-G of the Factories Act, 1948 and u/r 68 F & Y of the Gujarat Factories Rules. It is similar to the safety team.

See Part 11.3.1 of Chapter-6 for details.

3.87 Safety Team:

It is a group, which may be established by the works management for specific safety purposes, - e.g. inspections or emergency planning. The team should include workers or their representatives where appropriate, and other persons with expertise relevant to the tasks.

3.88 Security:

It protects the material, methods, manufactured goods and money assets by security personnel and Insurance. Generally it includes security staff (guards) in 3 shifts ie 24 hours for the protection of company assets.

Security should be distinguished from safety which is mostly concerned with protection from hazards by engineering and other control methods and as explained in part 3.80.

3.89 Site:

As defined u/r 2(m) of the MSIHC Rules, u/r 2(k) of the Chemical Accidents (EPPR) Rules and u/r 68J(1)(g) of the GFR, it means any location where hazardous chemicals are manufactured or processed, stored, handled, used, disposed of and includes the whole of an area under the control of an occupier and includes pier, jetty or similar structure whether floating or not.

Schedule-7 for notification of site should be referred under MSIHC Rules.

3.90 System Safety:

It is the concept 'to have an accident, there must be a hazardous or unsafe condition'. If that unsafe condition can be eliminated or suitably controlled, there will be no accident even if there is an error on the part of any personnel involved. Example is an interlocked guard, which prevents accident due to human error. To minimize accidents, it is necessary to eliminate or control any of the hazards involved at each stage of design, manufacture, test, operation and maintenance.

System safety requires auto controls to make the system so safe that human error may not result into accident.

3.91 Transport of Hazardous Chemicals:

It means movement of hazardous chemicals by any means over land, water or air.

See Part 14.2 of Chapter-18 and Part 6.2 of Chapter 28 for details.

3.92 Ultra-hazardous Operations:

Any person who conducts an operation that involves abnormal risk to others is strictly liable for injury or damage that results, even if these operations were conducted with care.

3.93 Uncertainty:

It exists only in our minds and has much the same meaning as doubt. Its opposite is often regarded as faith or firm determination.

3.94 Unsafe Act: -

It means either a positive act i.e. commission of an act or a negative act i.e. omission or failure to perform an act which a prudent man should not have done and which results in hazard, accident or injury. The unsafe act might be deliberate (mischief, sabotage etc.) or committed due to absence knowledge, ignorance or through forgetfulness (human error, mistake etc.). The unsafe act may be the sole accident cause or one of several causes. Examples are standing under suspended load, design mistake, starting machine without authority or warning, removal of safeguard, chance taking, wrong interpretation of safety rule, not following the safety precaution, poor vision or judgement etc.

Unsafe act is concerned with the human being and can be corrected by the action of the human being only. Training plays an important role. Even if the condition is fully safe, an accident may happen because of the unsafe act. At the root of creation of unsafe condition, many times the underlying cause is unsafe act i.e. human failure somewhere, which can be detected and corrected. According to H.W. Heinrich, @ 88% accidents are due to unsafe acts. He considered unsafe acts responsible for most of the unsafe conditions.

See Part 8.2.2 of Chapter-4 for details.

3.95 Unsafe Condition:

It means existence of a mechanical, physical, chemical or environmental condition, situation or state of affairs, which may cause hazard or accident. The unsafe condition might be the result of any unsafe act (human failure) or accidental failure or alteration of the safe condition. The unsafe condition may be the sole accident cause or one of several causes. Examples are, wrong design, no guard on dangerous part, no control of chemical process, no provisions of safety devices, poor light, poor ventilation, confined space, high noise etc.

Unsafe condition is concerned with the position, situation, existence or accidental alteration of the safe condition into such position, situation, existence or state of affairs leading to the causation of any hazard or accident. Such condition may be because of any unsafe act or not. Acts of God are unsafe condition. Unsafe condition can be rectified, repaired or made safe mostly by engineering controls.

3.96 Unsafe Production Factor:

It means an industrial agency or agency part, which under certain conditions may invite an injury or disease.

3.97 Vulnerability Models:

Vulnerability models are used to determine how people may be injured by exposure to heat load due to fire, blast wave due to explosion or toxic load of the released material. Such models are designed on the basis of animal experiments or on the basis of the analysis of injuries resulting form accidents, which have already occurred. Such models make use of a probit equation to forecast fatalities.

3.98 Wastes:

In its broad meaning, it includes collection, treatment, disposal, reuse and recycling of agricultural, animal, industrial, municipal and domestic wastes; procedures, engineering, plant operation and quality control methods applied in such processes and other aspects of waste management.

3.99 Water Pollution:

In its broad meaning, it includes all aspects of fresh water pollution (including ground water), pollution of water bodies, chemical and biological contaminants, marine pollution, detection, chemical analysis and monitoring of water pollutant.

3.100 Worst Case and Maximum Credible Scenarios,

The worst-case scenario (rarely possible) is defined as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an end point, eg catastrophic failure. It considers the failure of all control systems and release of the whole mass resulting in maximum damage.

Maximum Credible Accident (MCA) Scenario indicates most believable, reasonable, trust worthy, convincing, likely or possible accident scenario and damage distance based on it. MCA scenario takes into account the effect of existing control measures also. It considers the malfunctioning of the control system, opening of safety valve, flange joint, pipe line etc. and failing of some safety devise.

Alternative release scenarios are scenarios that are more (lively to occur than the worst-case scenario and that will reach an endpoint off-site, unless no such scenario exists.

The distance to the end point is the distance a toxic vapour cloud, heat from a fire, or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposures will no longer occur.

Computer models are more useful to determine such credible scenarios and to get the damage distances. Some latest computer models are CIRRUS, ARCHIE, PHAST, SAFETI and ALOHA etc. CIRRUS includes four important models in one package. These models are Source Term Model, Dispersion Model, Fire Model and Explosion Model.

4 MESSAGE OF THE WORD 'SAFETY'

The word 'safety' is defined in foregoing section. Now its message is philosophically explained below by each letter of its spelling.

S - Science for Safety of Self and Society.
A - Art and Action for Accident Avoidance.

F - Foolproof safety with Fail-safe devices including system safety. Factories Act is the safety backbone for industry.

E - Engineering controls are most important and must first be provided 'and maintained for safety.

T - Teaching and Training for safety to all concerned including workers and public.

Y - Young Person & Young Mind to work for safety. Yawl to save the humanity.

Five 'E's are stated as fundamentals for safety. They are Education, Engineering, Enforcement, Enthusiasm and Example setting. See part 8.4 of chapter-4 also.

Five 'L's are important-Learning, Leadership, Loyalty, Labour protection and Lawfulness.

Five'M' s are important - Man, Material, Machine, Money and Management.

Five T's are important - People, Protection, Productivity, Prosperity and Proficiency.

Philosophy of each of these words can be discussed with plenty of examples. They all need utmost attention.

5 PHILOSOPHY OF ACCIDENT CAUSATION

We are at the junction of old and new theories of safety philosophy which needs some clarification to avoid confusion and to make the safety approach more correct, more perfect and more powerful.

The concept of 'unsafe act as the main causative factor of more than 88% of accidents' has, now, become an old theory though it has not lost its full significance. This was more strongly propounded by H.W. Heinrich, the great philosopher of safety and accident prevention work. He estimated that 88% of 75000 accident cases reviewed were due to the unsafe acts of persons (Chapter-4). R.W. King and John Magid in their book of 1982 (see reference no. 10) also presumed human failing or unsafe act as an underlying cause of unsafe condition. This philosophy emphasizes the unsafe act as predominant factor, and continuous need to train our workers for their safe work practices.

The psychologists explained the theory of accident-proneness (Chapter-3) and held responsible these accident-prone people for majority of accidents. This has also led to the same old theory to find out the cause of accident in human behaviour (unsafe act) only.

This old theory is 'obviously picked up by majority of employers and they do not pay proper attention or invest sufficient money for safety because they follow this theory and say, 'Safely is mostly (88%) concerned with employee's behaviour and it is their duty to correct themselves, why should we invest much for only 12% of accident causes?' .This philosophy causes great harm to the progress of safety movement, and it needs to be discarded as early as possible.

But the research work was continued on the real causation of accidents and it is now inferred that the real cause of accident is an unsafe condition, which must be detected properly and removed in such a way that even human error or mistake may not cause any accident. Interlock or automatic guards, trips and alarms, checks and counter checks, level cut off, auto-stop, auto control and auto-correction etc. are ways and means to protect against unsafe conditions due to human error. This, theory is developed as a new engineering discipline and system safety. It is well explained by Willie Hammer and Blake (Chapter-4).

Willie Hammer states, "Observation over the years has shown that this premise (accident-proneness) is incorrect. There are persons who have more accidents than other persons in similar situations." Explaining the new concept of system safety he says "system safety conceived that accidents could be caused by personnel error, malfunctions and failures of equipment, dangerous characteristic of equipment or adverse environmental conditions. Personnel error could have been by designers, test and maintenance men, workers or anyone connected with the process or product. To minimize accidents, it is necessary to eliminate or control any of the hazards involved at each stage of design, manufacture, test, maintenance and operation. If Heinrich's data were re-examined in accordance with these newer ideas, it might be found that 88% of the accidents were probably due to causes other than error by the person immediately involved."

Blake has also criticized the ratio theory of Heinrich as fallacious as it rests on a false assumption that work connected injuries are the result of either unsafe conditions or unsafe acts. The real reason in most of the cases is a combination of correctable unsafe condition and faulty behaviour and frequently there are multiple factors of both. To classify accidents as either unsafe act or unsafe condition is over simplification and many times data is not available to find out any single cause and the causation has a sequence of events creating hazard or accident as a result of combination of unsafe condition and action. Thus accident classification requires high skill and observation and must be proper.

The real Philosophy of Accident Causation:

It can be concluded as under:

1. It is true that unsafe condition and unsafe action, both, exist and play their role in accident ' causation.

2. There mayor may not be any single cause as 'unsafe condition only' or 'unsafe action only'. Proper fact data must be searched to find out the real cause of accident. In want of sufficient or correct data, no conclusion should be drawn about the real or sole cause of accident.

3. 'Why did the man make mistake?' should be thoroughly examined in depth and working or environmental condition must be detected as a root or real cause of his human failure. The poor vision and poor illumination, both, are unsafe conditions, and can be rectified by necessary spectacles and increase of light.

4. If the causes are combined, classify them and try to remove them priority wise.

5. Unsafe condition has more accident potential and can lead to a serious accident. Therefore it must be detected first by various safety inspection methods or safety audits and must be removed by proper engineering controls. Unsafe conditions have caused major accidents in past.

6. Unsafe action requires behavioural or psychological study of workers, which should be carried out and unsafe action should be rectified before it may cause any unsafe condition, hazard or accident. The purpose of this causation analysis is to train the workers properly and to minimize man-made hazards or unsafe conditions timely.

7. All causes of accident should be considered together, instead of analysing and separating as unsafe action or unsafe condition and blaming one or the other. It is not cheaper to prolong hazard than to remove it.

8. New study of accident causes reveals that 3% were due wholly to mechanical cause, 2% due wholly to unsafe acts "and 95% to a combination of both the causes. The percentage may vary. to

some extent in different case studies, but it is the best approach to safety that mostly the causes are combined or complex and they all should-be removed wholly.

9. The concept of accident proneness is not the real cause of majority of accidents. This concept has historical value (as it was originally derived from psychological studies), but it requires proper understanding and its causes (including faulty working conditions) should be removed. This concept is explained at length in the next Chapter.
10. Employer's mentality based on old theory of "unsafe act as predominant accident factor" must be removed and they should follow the new concept that percentage of unsafe act or unsafe condition are not important, the causes are mostly combined, are equally important and require self motivated sincere efforts and full money investment in removing all of them and making the man, machine, material, manufacturing process and all environment fully safe and healthy. Good working conditions contribute less error and less hazards. Information and training to detect and remove hazards at any level are utmost necessary.

11. It should be accepted that majority of accidents happen with contract workers as they are illiterate, untrained, unskilled, less equipped and poorly supervised. Therefore more attention must be paid for their safety.

6. PHILOSOPHY OF TOTAL SAFETY CONCEPT:

Based on above discussion, phylosophy of **total safety concept** should be as under:

1. Safe and clean work place and working conditions.
2. Safe and Ergonomic design and application to reduce health hazards.
3. Safe work method, job performance and the job itself.
4. Detection and assessment of risk, deciding what precautions are needed and application of eco-friendly process technology and hazard control technology.
5. Prevention and control of situation and environment including exposure to hazards and well maintenance of all control measures.
6. Improved methods of selection, training, placement and supervision of workers.
7. Periodical medical health check up and follow-up of medical advice for workers.
8. Periodical psychological study of human behaviour for safety.
9. Public awareness and preparedness programs i.e. community involvement for public health & safety.
10. Periodical review of all safety programmes and necessary change and improvement where required.

This new philosophy of safety is the f oundation of safety structure and safety culture.

E X E R C I S E

1. Explain the Objectives of Philosophy of safety OR Explain the Nature and Subjects of safety philosophy.

2. Is the term 'accident' defined under the Factories Act? Give any two definitions of 'accident' and explain them with illustration.

3. Discuss the term with example:

1.	Accident.	2.	APELL.
3.	CASH	4.	Dangerous Occurrence.

5 Environment.
6. Error.
7. MAH installation
8. Injury.
9. HSMD
10. Mistake
11. Near miss
12. Occupational health
13. Oversight
14. Product liability
15. Safety Management System.
16. In-place protection.
17. Safety premises
18. NHWIS
19. Safety audit.
20. Major accident.
21. System safety
22. Risk Assessment
23. EMP
24. Ecology
25. Noise pollution
26. ISRS
27. Vulnerability Models

4. Distinguish with example:

1 Accident & Major accident.
2 Emergency & Disaster.
3 Hazard & Risk.
4 Error .& Mistake.
5 Analysis & Assessment.
6 Near miss & Accident.
7 Loss control & Loss prevention.
8 Occupational Health & Hygiene.
9 Onsite & Offsite emergency plan.
10 Safety & Security.
11 Safety Manager & Risk Manager.
12 Unsafe act & Unsafe condition.
13 Risk Counter & Damage distance
14 Consequence & Vulnerability Analysis
15 The Worst Case scenario and MCA scenario.

5. Explain the real philosophy of safety emerging from old and new theories.

6. Explain the philosophy of 'total safety concept'

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CHAPTER – 3

Safety Psychology

THEME

1. NEED OF SAFETY PSYCHOLOGY

Safety is mostly concerned with control of accidents (control includes prevention). The accidents are due to unsafe conditions or unsafe actions or their combination. As per H.W. Heinrich's theory, majority (88%) of the accidents are due to unsafe actions of the workers. In modern plants, where the working conditions are good and well maintained, some accidents take place due to unsafe action i.e. human behaviour of the workers. Therefore it is an important task to study this unsafe action or human behaviour, to find out its causes, effects and remedial measures and to remove them. *It is important to study first the human machine and its behaviour before studying any machine made by him*. **Psychology** and **psychologist** do this task. This shows the need of psychological study in the field of safety also.

At present knowingly or unknowingly psychological principles are applied in accident control theories, but, well study of psychology or human mind brings perfection in them. All safety officers, engineers, supervisors and inspectors should have good knowledge of psychology to understand and rectify the human behaviour, which is one of the causes of hazard occurrence and accidents. Need of applied psychology for safety in industry should be properly recognised.

Psychological safety measures put stress on information, instruction, training and supervision for safe performance, which is also a statutory need (Sec. 7A) under our Factories Act, 1948.

Human Resource (Psychology) Department of industry should organise safety-training programmes for all types of workers.

2. PSYCHOLOGY AND ITS BRANCHES

Psychology is a study of human behaviour and includes all behavioural aspects viz. mind, body intelligence, attitude, aptitude, morale, performance, proficiency, skill, learning, training, motivation, aspiration, inspiration, satisfaction, liking-disliking, action-inaction, fatigue, boredom, absent mindedness, accident-proneness, effect of working environment, labour policy, management, age and sex, individual differences, conflicts, personality and interest, human error and accidents, worry, unrest, synchronisation of mental and muscular faculties, mental and physical reactions, sense of duty or responsibility, motive or lack of motive, humanitarian impulses, disposition etc.

Psychology is defined as study of human (also animal) behaviour with the aid of scientific methodology. It is an art and science of mind. It collects facts of human behaviour by using scientific methods ' viz. experiment, observation, time-motion study, field study, case study etc.

Psychology is a branch of philosophy and is established as an independent branch. Like other sciences, it also aims to reduce all phenomena (mostly human) to cause and effect. It accepts causation in behaviour as a fact. It demands analysis of events, situation and past experiences to correct the behaviour

It has two aspects, scientific and applied. In its scientific aspect it considers research and discovery of information related to human behaviour. When such information is applied to practical problems of human life, it is said an applied or professional aspect of psychology.

Branches of psychology are given in Table 3.1.

Table 3.1 : Branches of Psychology

	Branch Known As	Area of Study
1	Engineering psychology or Human factor psychology or Human Engineering	Human behaviour as a function of self or personal factors like physical traits, mental traits, ability of work, attitude, aptitude, morale, frustration etc. Human behaviour as a function of work situation or environmental factors like temperature, ventilation, light, noise, vibration, ergonomics, job situation, fencing, guarding, house-keeping, training etc.
2	Clinical or counseling psychology	Abnormal aspects of behaviour
3.	Educational Psychology	Process of learning and education
4.	Development psychology	Development in behaviour with growing age
5.	Social psychology	Influences of society (other people or groups) on an individual's behaviour.
6.	Experimental psychology	Experimental method to study behaviors and to discover principles that govern behaviour
7.	Personality Psychology	Human personality
8.	Industrial psychology Or Applied psychology	Application of principles of psychology in trade, business and industry.

3. INDUSTRIAL PSYCHOLOGY

Industrial psychology is concerned with the study of human behaviour in those aspects of life that are related to the production, distribution and use of the goods and services of our civilization.

Application of the psychology to trade, business or industrial field is called industrial psychology, and generally covers the following areas given in Table 3.2.

Table 3.2 : Sub - branches and Areas of Industrial Psychology

	Sub-Branch	Area of Application
1	Personal psychology	Selection, training and supervision of people in industrial / business setting. It also studies communication.
2	Managerial psychology	Problems of management in industry.
3	Engineering psychology Or Human Engineering Or Human factor Engineering or Ergonomics	Effect of working condition, situation or environment and includes factors like over crowding, light, ventilation, temperature, sitting arrangement, design of machine, tools, controls, gauges, switches, equipment, work method, job situation so as to be safe and convenient to the workers.
4	Consumer psychology	Relationship between manufacturer and consumers of their products or services.
5	Organizational psychology	Total (overall) functioning of an organization, factory, office, management etc. including topics like motivation, leadership, communication patterns, work group by dynamics, organizational structure, process etc.

Subjects of Industrial Psychology:

Ordway Teed says, "Every major management problem is in part psychological."

Herbert Moore -describes in his book six industrial problems for psychologists to solve:

1. Employing the worker.
2. Educating and training the worker.
3. Caring for the health and safety of the worker.
4. Helping to provide for the economic security of the worker.
5. Establishing workable employer-employee relationship and
6. Cooperating with the advertising and sales forces.

For proper selection of a right man for the right job, various tests are suggested such as service commission's tests, intelligence tests, general ability tests, special ability tests (mechanical and electrical), personality tests, aptitude and attitude tests, achievement tests etc. Various incentives are also suggested to motivate workers.

Main Subjects of Industrial Psychology:

Appraising and training the worker, accident-proneness, causes and prevention of accidents, employee fatigue and boredom, the problem employee, motivation the psychological factors in labour turnover, consumer contracts and selling -are the main subjects of industrial psychology.

4. SAFETY PSYCHOLOGY

Safety psychology is a part of industrial psychology and can be explained as under:

4.1 Meaning and Aim:

Safety psychology is a study of human factors and behaviour contributing to the causation of hazard, accident or unsafe environment or situation and the application of remedial measures to prevent and control them by improving human behaviour for safe job performance and relations with others to maintain the safety.

Thus safety psychology studies a **person** why he commits accidents, under what circumstances and what are other contributing factors affecting his behaviour or making him accident prone and how such behaviour can be corrected to rectify his unsafe actions to achieve the goal of overall safety which includes the techniques of accident prevention.

Fig. 3.1 Safety of human being at the centre

Tile human being is at the centre of such study and therefore it is called the human engineering. See fig. 3.1. The concept of safety as human engineering is its psychological part. It aims at the rectification of human errors, human factors and unsafe actions as the causes of accidents or unsafe environment. H.W. Heinrich says in his old book on Industrial Accident Prevention that psychology lies at the root of sequence of accident causes. For details see next chapter.

4.2 Present Psychological Safety Problems:

Field of safety psychology is applicable to employer and employee both. Accidents are the results of faults of employer or employee. The main responsibility to provide and maintain safe working conditions, safe environment and protective equipment lies upon the employer, however, the practical field of effort for prevention through psychology and use of .protective equipment, is applied largely to the employees. The employees being more in number render more chances of human faults. Therefore it is their great, individual and group or collective responsibility to minimise their human faults to prevent accidents and to maintain safety.

Present psychological safety problems can be divided in two parts: Employer's problems and Employee's problems. Ultimately they create problems for society and nation also.

4.2.1 Employer's Problems:

Employers' expectation or fear from the employees not only in the form of production targets, but, in the form of attitudes, loyalties and cooperative efforts, is as important to the psychologist as the employers want to know about the resources, desires,. motivation and capacities of their employees.

Workers' disobedience, indiscipline, sabotage, mischief, non-using of safety equipment or appliances or damaging them, not following the safe close down of the plant for the purpose of safety, and not even allowing others to carry out such safety duty and practising strike or go slow to the extent of endangering safety of self, others and surrounding public are the present psychological problems creating worries for employers. They expect help from the Government which ought to be given, but, it must be noted that the only effective key to correct or improve human behaviour lies in die self discipline or self-efforts and outsiders can contribute little if the wrong doer is firmly determined not to improve himself. The Government may help in die field of law and order but it can hardly improve the human behaviour, which needs special efforts.

There are some statutory provisions in the Factories Act 1948 to punish workers for their offences regarding safety, but the Governments are reluctant to operate them against the workers. Even if they are operated, no worker will give evidence against a worker and other witness if come forward, they may be attacked by the mob-mentality. Thus in the atmosphere of deliberate indiscipline or mischief in the field of safety, really, it is a challenging problem for psychologists to solve in the interest of safety. Trade unions should also contribute to solve this problem.

The workers must understand that safety of them and others lie in their hands. Safety is a subject of co-operation and construction and not destruction. If safety is not maintained, nobody will be happy and they themselves may lose their limbs or lives. Compensation cannot bring the life back. Safety of anybody's life is of prime importance. No human behaviour is morally or legally permitted to endanger or take away anybody's life or to cause damage to plant, machinery, production or environment, as they all ultimately result in the national loss. Let us always maintain safety and solve our problems in safe atmosphere only. Let us perform this safety-duty first, enjoy the right and let others also should enjoy their rights. This is the only good motivating force to mould the human behaviour to maintain safety. Employers' regular efforts to give such type of HRD training to their employees can be useful.

Apart from employer's duty towards workers, new legislation during last ten years has imposed duty towards the public also. Under the Factories Act, Environment (Protection) Act, Public Liability insurance Act and Chemical Accidents (EPPR) Rules, die general public is to be informed about the hazards; controls and their role in emergency. Any citizen or member of a Crisis Group can demand such information from employers. This situation has created worries for the employers and they seem to be reluctant in providing such information to public. In case of a major accident affecting public, the Police and other authorities may prosecute them. A solution to this problem is the willing compliance of law only.

4.2.2 Employee's Problems:

Employees' expectation from the employer not only in the form of pay, but in the form of security, opportunity for advancement and protection, is as important to the psychologist as what they want for themselves in the form of self-expression, recognition and acceptable working conditions and environment.

It is the fact with many small and medium-scale factories that workers' expectation, as stated above, is rarely .fulfilled. The exploitation of poor, uneducated, unorganised and mostly contract workers are still continued and they have to work long working hours under bad and unsafe working conditions and environment. Most of the educated workers do not get satisfactory wages and are de-motivated. Trade unionism may change their attitudes. Even statutory requirements for health, safety and welfare are not provided for. They have no recognition, self-expression, protection, security or opportunity. They work only because of their livelihood, economic need or helplessness.

The need, and work of a Safety Officer are still not recognised wholeheartedly by the majority of the employers. This situation discourages and de-motivates the Safety Officers. Due importance must be given to all safety employees and their work.

In spite of factory and safety legislation and inspectorate, the working conditions for workers are found generally not good. With few exceptions in some good factories, most of the places need improvement for safe environment. The machines are not guarded, floor openings not covered, safe means of access not provided, safety devices neither provided nor working, occupational diseases go undetected and unreported, dusting, fuming, gassing and pollution constantly pollute the atmosphere, pressure vessels, lifting machines and other dangerous machines and processes are not fully safe and they cause many accidents. The same is the case with many chemical vessels, their fitting and maintenance. Workers also do not complain much, as they see such situations since long, as regular affairs, routine matters or have less hope for improvement.

Who is to blame for this? After all human beings are involved and they blame each other. Employers say they provided the safety arrangements but the workers do not maintain them. Some say they have no money to invest for costly safety equipment and the Government should give subsidy to them. Workers say opposite, that the safety devices are not provided or not working since long and nobody hears their complaints. Factory inspectors prosecute for many violations but mostly for other than safety. Only in case of accidents or special cases they prosecute for safety. Their finding is such that many employers do not .provide or maintain safety devices for many reasons, and strict and repeated follow-up is not possible due to shortage of staff, time and manifold work. People blame the inspectors also. This is the real picture -posing psychological problems at many fronts. The nature or extent of problems may vary with the place and person, but the general picture remains the same.

Blaming each other will not solve the problem. All are right or wrong to some extent. It is doubtlessly, the primary duty of all employers to provide and maintain the safety requirements. There should be no defence for this. Safety expenditure must be planned from the beginning and should be provided every year. Safety committees should be formed with the inclusion of workers representatives to review safety conditions. The unsafe conditions and actions must be removed by joint efforts. The workers, supervisors and all workpeople should strive for safety. Preventive-and corrective maintenance should be carried out regularly. Such should be the attitudes. The Factory Inspectorate should be strict for safety compliance and should give all guidance for safety knowledge. Trade unions should also contribute much including safety wareness and training. The human behaviour for safety must be motivated and improved.

5. ACCIDENT CAUSATIVE FACTORS

Main Division of Factors affecting Work:

Main factors affecting work performance or influencing actions of people are broadly divided as (1) Environmental factors and (2) Human factors.

The **environmental factors** are due to (1) Physical work and (2) Physical, chemical, biological and ergonomic environment. The physical environmental factors are heat load due to heat, humidity, thermal radiation, air changes, velocity, ventilation, illumination, noise, vibration, etc. The chemical factors are corrosive, toxic, flammable, or explosive substances, dust, fumes, gas etc. The biological factors are bacteria, virus and microorganisms. The ergonomic factors are layout and design of machinery, equipment, tools, controls, workplaces and housekeeping.

The **human factors** are due to two aspects (1) Physiological and (2) Psychological.

The **physiological factors** are physiological. fitness of an individual worker estimated from his Maximum oxygen uptake capacity. Sex, Body build, Age, Muscular work. Posture, Clothing, Nutrition, Training, skill, and Occupational workload.

The **Psychological factors** are Attitude, Aptitude, Frustration, Morale, Motivation, Individual differences etc.

Industrial accidents are either due to **unsafe conditions** (situation or environmental factors) which include mechanical causes (unguarded machinery, defective equipment, dangerous situation etc.), chemical causes (toxic exposure, dust, fume, fire, explosion and variety of ill-effects due to hazardous nature of chemicals, their storage, processes and equipment), and physical causes (physical workload, working hours, heat, light, noise, vibration and working conditions) physiological causes (Age, sex, body-build, posture, physical fitness, health, physical fatigue, nervous strain, sickness etc.) or due to unsafe actions which include psychological causes (motivation, skill, training, carelessness, recklessness, habit, worry, emotional upsets, irresponsibility, poor attitudes etc.).

Generally engineers, industrial hygienist and safety officer try to remove unsafe conditions and a physiologist and psychologist deal with unsafe actions. The details of physiological factors are discussed in Part 2 of Chapter-24.

The psychological factors being the main subject of this chapter are discussed below:

6. GENERAL PSYCHOLOGICAL FACTORS

The psychological factors (a part of human factors), affecting human behaviour or influencing actions of people for work performance are many. The human attitudes and aptitudes, frustration and conflict, morale, individual differences, acclimatization, skill and training, need and job satisfaction, motivation and aspiration, participation, incentives and job evaluation, fatigue, boredom and monotony, accident proneness, group dynamics, labour policy and turnover, personal selection and classification, problem worker etc. are the main psychological or personal factors affecting human behaviour. Some psychological tests are also carried out to measure some of these factors.

H.W. Heinrich's study of accident analysis emphasised that 88% of the accidents were due to unsafe act of the people,, and above factors were the main sub-causes or reasons for such unsafe acts, and therefore the study and application of remedial measures from this psychological point of view can prevent 88% of the accidents which is the great service of psychology to the industrial safety. No officer working for safety should ignore this fact. He should pay proper attention to correct the human behaviour of self and the workers due to these factors by giving constant training to them. These factors are explained below:

6.1 Attitudes:

Norman Maier states that an attitude is a kind of mental set, posture or bent. It represents a predisposition toward opinions. Suppose a worker is asked what he thinks about a guard on his machine or temperature, or lighting in his workroom, his reply is noticing but his opinion. The attitude is more general and influences his opinion. Knowledge of attitudes of workers helps the management to predict their opinions.

An attitude is a frame of reference, which affects our opinion of the objective fact. A change in attitudes may radically change opinions. Attitudes determine opinions and prejudices. Conservation and radicalism are two extreme kinds of attitudes. People with these differing attitudes have divergent opinions about the same facts. Disagreements about facts are also possible. Our various prejudices offer many illustrations of attitudes that determine the meanings, which facts may assume.

Attitudes reconcile contradictions. With the proper attitude as a background, intelligent people can reconcile others' contradiction. A clever and experienced Safety Officer or supervisor will reconcile contradictory opinions of workers and management about the efficacy of a particular safety device or a protective equipment, if he has knowledge of their attitudes. Such knowledge of attitudes helps him to find out the real cause of an accident.

Our loyalties and our prejudices are frequently in-group and out-group attitudes, respectively, and they provide sources of error in arriving at objectively sound conclusion. An attitude 'we are right and others wrong' has caused many accidents, and pose hindrances in solving problems.

Attitudes are usually associated with likes and dislikes and consequently have an emotional content. Our moods are temporary predisposition toward having certain emotional reactions. Our moods influence our attitudes. In one mood, a supervisor will fly into a rage at a worker's mistake, while in a different mood he may pass it off a something that could happen to anyone. Mood and attitude are difficult to differentiate. A mood is temporary and depends upon one's physiological condition such as poor health, loss of sleep, hunger etc. Emotional or psychological upsets influence one's physiological condition and produce moods, which predispose him to make unpleasant reactions.

The reason and argument may or may not influence attitude. Generally, a man defends his opinion and shows no readiness to change it even though his all points are answered. People prefer their wishes and desires and are not ready to be convinced by logic.

Personality differences determine the type of attitude. Some people are inclined toward radicalism, others toward conservatism, and still others avoid extremes. Likewise, differences in social dependability, decisiveness, emotionality, sex, intelligence and experience etc. influence attitudes on specific topics.

Various methods are used for measuring attitudes, and experimental findings are recorded.

Industry cannot afford to make radical changes, which will backfire. Use of attitude scales (devised by Thurston), opinion polls, suggestion boxes, interview method, safety committee etc. are industrial practices to know employee attitudes, grievances, suggestions, personnel counsellors etc. and thus to make it possible to prevent open violence or mass work stoppages.

6.2 Aptitudes:

Aptitude means inclination or fitness. Aptitudes are human characteristics or abilities related to the capacity to develop proficiency on specific jobs. These aptitudes can be grouped into five classes:

1. Mental abilities.
2. Mechanical and related abilities.
3. Psychomotor abilities.
4. Visual skills and
5. Other specialized aptitudes.

Various aptitudes tests are used in personnel selection and placement.

Mental ability means intelligence. The field of mental ability tests has been explored like other areas of testing. Some mental abilities are verbal comprehension, word fluency, memory, inductive reasoning, number facility, spatial visualisation and speed of perception. Thurston's studies suggest that primary mental ability can be measured by a test specifically designed for that ability.

Mechanical ability includes certain mechanical aspects, such as mechanical comprehension and the understanding of mechanical principles and these are motor or physical skills such as muscular co-ordination and dexterity. Thurston said it a complex of intellectual abilities.' Mechanical ability tests are used to select employees for jobs that require a mechanical 'knack' such as in the maintenance or setting up production machinery or in the repair of household appliances.

Psychomotor tests are used to measure muscular abilities or combinations of sensory and muscular abilities. The term 'psychomotor' includes dexterity, manipulative ability, motor ability and eye-hand coordination and other aspects of muscular performance. Various psychomotor ability factors have been identified such as control precision, multi-limb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity, finger dexterity, arm-hand steadiness, wrist-finger speed, aiming etc.

Every industrial job requires some degree of vision and many jobs require a high degree of skill in some particular visual function. Colour discrimination is also an important factor. Various vision tests are available. Mechanical and psychomoter abilities, visual skills and special aptitutes are essential for safety work.

Specialised aptitudes or attributes include the tests of clerical aptitude, reading speed, comprehension, vocabulary, perceptual speed etc.

6.3 Frustration:

Frustration means defeat or disappointment toward success. Any interference with the achievement of goal causes frustration. Characteristics of frustrated behaviour are suggestion, regression, fixation or resignation and it depends upon individual's tolerance, work pressure, situation etc. If a worker meets with an accident on a power press machine, he becomes nervous to operate it and this may result in repeating the accident. By providing the effective guard and explaining him about its proper use, his frustration can be gradually removed.

Frustration brings morale degradation, which in turn, increases accident rate.

A frustrated person responds in two ways:

1. Adaptive response i.e. acception of situation and substituted goal.
2. Maladaptive response i.e. the person may continue trying to reach the unattainable goal or he may give up trying to reach any goal whatsoever. He may show withdrawal response, attack response, limitation response or substitution response.' As propounded by Scott (1966) in his activation theory, human organism needs stimulation and variety in work. Environment without this motivation will suffer and frustration may result. Change or variety in job and stimulation may reduce frustration.

In industry there are many instances creating frustration. Not providing proper working conditions, tools, equipment and PPE despite of demand, not providing necessary guards and safety devices on machines and not giving promotion, increment, recognition and status as per requirement can cause frustration. All such dissatisfying factor should be detected in time and appropriate remedial measures including management functions should be adopted. Some situations leading to frustration and techniques of identification and management ar given in Table 3.3.

Table 3.3: Frustrating Situations and Remedial Measures

	Situation		Identification		Management
1	Increasing accidents to an individual	1	Check job or m/c condition.	1	Remove the defect.
		2	Check surrounding space, light etc.	2	Improve them.
		3	Study type of tool, equipment etc.	3	Use ergonomic design, standard tool, equipment etc.

		4 5	Study work method. Study his behaviour.	4 4	Correct it Employ psychologist and take his advice.
2	Work quantity (goal) excessive.	1 2	Study results, spoilage, effects of workload on body etc. Carry out time motion study.	1 2	Reduce the work reasonably (make the goal attainable). From the result, adjust the work, machine, tool etc.
3	Work quality is not obtained in spite of good efforts.	1 2	Check the material. Observe work method, machine, tool etc.	1 2	Have good quality material. Give training as required.
4	Worker becomes irregular, inattentive or reluctant etc.	1 2	Discuss with him or others to know the reasons Try to know family problems	1 2	Try to remove the reasons by giving more pay, promotion, making permanent etc. Try to solve such problems to the extent possible.
5	Monotony, fatigue etc. due to same type of work for a longer time and frustration due to that.	1 2	See the work speed or results. Ask the worker about his opinion.	1. 2.	Give change in job, place, department etc. to find new atmosphere. Give stimulation necessary.

6.4 Conflict:

Conflict means violent collision, a struggle or contest, a mental struggle etc. In industries conflicts of both the types - physical and mental - occur.

Conflict reduces productivity. Conflict may arise due to attitude, jealousy, bad behaviour, working condition / environment, power mongering, labour relation, favouritism etc.

To reduce conflicts, provide all necessary and better tools, equipment, guards, safety devices, safety clothing, protective equipment and welfare facilities for safe, healthy and satisfactory environment.

Conflict may occur between employer and contract workers if the later are not considered at par with the company employees in respect of providing safety equipment, training and other facilities. Therefore facilities of safely, health, welfare and working hours should be equally given to them.

Similarly safety committee meeting should not become a platform for conflicts. Safely is not a matter of dispute or conflict. Difference of opinion on any matters of safety should be settled by consulting experienced safety manager or consultant.

Some situations leading to conflict and techniques of identification and management are given in Table 3.4.

Table 3.4 : Situations of Conflict & Remedial Measures.

	Situation		Identification		Management
1	Supervisor (boss) favouring one group and disfavouring another group.	1 2	Try to find out labour unrest. Find difference in output of two groups.	1 2 3	Remove the reasons. Change supevisor if necessary. Explain Supervisor's a behaviour if he is justified.
2	Wage difference for same & similar type of work.	1 2 3	Labour unrest. Complaint. Litigation	1 2 3	Resolve by group discussion and dialogue. Give justification Attend properly.
3	Settlement with workers delayed.	1 2	Observe go slow, strike etc. Labour unrest.	1 2	Try to make settlement. Justify delay
4	Union rivalry.	1 2 3	Entry of new union and new demands. Workers' struggle. Effect on work.	1. 2. 3.	Justify right union. Take legal action. Settle the issues if possible.
5	Disciplinary action against worker (s)	1 2	The worker's reaction Support of other workers to him.	1. 2.	Justify before taking action and justify after action. Convince others.
6	Go slow, strike, Non-cooperation, Labour unrest.	1. 2.	Find reasons of dissatisfaction. Effect on work of efficiency.	1. 2.	Remove reasons. Provide safe / better tools, equipment, facility, condition etc.

6.5 Morale:

Morale is a mental condition in which both personal and group features are involved. Requirement of high morale, according to NRF Maier are (1) Individual's firm convictions and values which make life worth while and give energy and confidence to face the future (2) He must be aware of a job to be done to defend or extend his values and (3) His values must be in essential agreement with those of his group and there must be a co-ordination of effort in attaining objectives.

Guion has defined morale as 'the extent to which an individual's needs are satisfied and the extent to which the individual perceives that satisfaction as stemming from his total job situation.' This definition covers the personal aspect only, it does not cover the 'group' reaction aspect, which is also essential. G.W. Allport has defined national morale as an individual attitude in a group endeavour.

Thus the term morale signifies high values of life and a team spirit of a group, society or nation. The Indian concept stresses upon ethical values and loyalty, which gives high respect towards others.

Good morale is a resistance to frustration or defeat and poor morale is apathy or resignation.

Good working conditions are more conductive to good morale in industry. Type of supervisor and safety officer, ventilation and temperature, lighting and colour, guarded machinery, safe environment, sanitary and welfare facilities and attractiveness of the shop create an atmosphere which influences the morale of the workers.

Psychological factors influencing morale are mutual sacrifice, participation in-group activity, experience of progress toward a goal, tolerance and freedom within the group and confidence in leaders. These factors explain that morale is largely a social phenomenon and is subject to social influences. Morale in respect of an isolated individual requires high motivation, persistence and self-confidence.

In industry the morale of workers is influenced by –

1. Working conditions as mentioned above.
2. Behaviour of foreman, supervisor, safety officer and other leaders, with the workers.
3. Training programs (including motivation) for workers.

6.6 Fatigue, Boredom and Monotony:

These are another psychological factors affecting human behaviour.

Fatigue is defined in different ways:

It is a reduction in the ability to do work because of previous work - NRF Maier.

Decrease in the capacity to do work - a loss of efficiency.

Decrease in interest or willingness to work- a feeling of ennui or weariness - Starch.

More or less or complete loss of irritability and responsiveness of a tissue - Freeman.

Condition of mind resulting from prolonged mental activity - Wilson.

It is a failure to maintain physiological or organic equilibrium - Dill.

Thus fatigue is a physiological as well as psychological phenomenon. The evidence of physiological fatigue is found in muscle, nerve, blood and brain. It is measured by ergo-graph studies, which explain the nature of fatigue. Hourly accidents' and hourly production are used as a measure of industrial fatigue. Rest pauses, working hours and work shift have effect on fatigue.

Psychological fatigue denotes factors difficult to achieve, which cause work decrement. It includes the falling-off efficiency of work, which is commonly called as mental fatigue as well as boredom and monotony. Motivation can decrease fatigue. Improvement in environmental conditions such as workplace, workday, position, vibrations, training, job-change, water supply, clothing, food, sleep, rest pauses etc. can also decrease fatigue.

Boredom is another similar term with minute distinction as shown in Table 3.5:

Table 3.5 : Distinction between Fatigue & Boredom

	Fatigue	Boredom
1.	Physiological depletion	Mental dullness
2.	Decreases capacity for work.	Decreased interest in work.
3.	Conscious inability	Feeling of incapacity
4.	Result of too much work challenges	Result of absence of work challenges.
5.	Spirit is willing but the flesh in	Flesh is willing but the spirit is

	weak.	weak.
6.	Desire for rest	Desire for change.
7.	Somewhat measurable	Difficult to measure.

Repetition and monotony contribute to boredom.

Monotony is also a mental phenomenon affecting work. Monotony effects are more during the middle of the work period and disappear in anticipation of the end of the period. The extent of monotony depends upon repetitive nature of the task and degree of attention required.

Methods to eliminate boredom and monotony from industry are -

1. Exchanging jobs.
2. Relating the job to the larger picture.
3. The use of sub-goals.
4. The use of pacing methods and automatic work habits.
5. Rhythmical habit pattern. Piece-rate procedure.
6. Creation of favourable attitudes.
7. Improvement in working conditions and housekeeping.

6.7 The Problem Employee:

Some people think that 'Every human being is problematic. As every child in a home is a problem child, every employee is a problem employee.' Every addition of personality to an industry means increase in number of problems. Emotional and rational forces of workers create tense situations. This problem needs psychological study and solution.

Why an employee becomes a problem employee? The contributing factors are dissatisfaction of any type; foreman, supervisor and bosses of undesirable types, environmental factors and the employee himself.

Dissatisfaction may be due to many reasons lack of job security, irregular payment, less pay, breach of seniority rules, wrong works of superior, wrong favour, inactive shop committee, many promises without fulfilment, unwanted work changes, social unbalance etc. These should be removed.

Defects in foreman, supervisor and bosses are Incapable to manage others and to get co-operation from them, self-centred person, egoistic person, emotionally immature person, fault finding and bad tempered person improper regard for authority etc.

The environmental factors are partly due to the nature and attitude of co-workers and partly due to the physical conditions.

Maladjusted employees are - Unequal or superior to their task, persons with pronounced self-assertive tendencies, emotionally distinguished or immature persons, lacking in skill, ability and knowledge and lacking in job wisdom viz., insubordination, unreliability, absenteeism, laziness, trouble making, intoxicating, violation of rules, carelessness, fighting, misconduct, dishonesty, loafing or sleeping, dissatisfied, habitual loiterer, shopper, slow, agitator etc.

Fisher and Hanna have divided problem people in three groups:

1. The insane.
2. Disturbed by psychoneuroses such as paranoid personalities, inadequate personalities and emotionally unstable.

3. Milder forms of emotional turmoil. This group includes mostly the problem employees such as dissatisfied with their jobs, restless, absentminded, pessimistic, distractible, worrying unduly over minor details and unable to form decisions.

To discover problem employee, various equipment, tests, questionnaires and controlled interviews are suggested. It is advisable (particularly in the interest of safety) to discover such employees before their recruitment. Subsequent finding will create problem, as it may be difficult to remove them because of legal, union and other reasons. Subsequent remedy is to care and train them.

7. INDIVIDUAL DIFFERENCES

It is a matter of common experience that people differ from one another. Their physical appearance and traits such as height, strength, intelligence, ability of work, memory, speed of reacting a signal, honesty or emotional stability and mental traits, personality traits, sensory capacities, muscular co-ordination etc. are some of the factors of individual differences.

7.1 Classification of Differences:

Joseph Tiffin and Ernest McCormick have classified individual differences in work performance due to following variables:

1. **Individual Variables** (Human Factors): Aptitudes, personality characteristics, physical characteristics, interest and motivation, age and other personal variables.

2. **Situational Variables** (Environmental Factors) : subdivided as
   (A) Workplace variables: Physical environment, workspace and arrangement, design and condition of work equipment and methods of work.
   (B) Organisational and social variables: Character of the organisation, type of training and supervision, type of incentives and social environment.

Psychologists have tried to determine the ultimate cause of individual differences among people. They have shown two general categories of. heredity and environment. Generally the people are influenced by the combined effect. Heredity has more effect on height, weight, strength and appearance. Environmental factors have dominant effect on personality traits and interests.

7.2 Perception of Danger & Risk:

Different persons have different degree of perception of danger and risk. Due to individual differences capacity of understanding and identifying the hazard differs. While crossing highway, one person may have correct judgment of chances of accident looking to the distance and speed of the vehicles coming from sides. Different workers have difference of opinion or judgment regarding-hazard arising out of moving machinery or risk from chemicals.

Danger and risk are defined in pera3.14 and 3.75 respectively of Chapter 2. Important is the response time required for quick action to protect our self or others from the danger or risk. Slow response time indicates more chances of accidents and vice-versa. Safety training can help to improve ability of good perception of danger and risk and help to minimize accidents. Some examples of perception of risk is given in the following table:

Examples of perception of Risk.

Sr.	Hazard	Risk	
		Chance, Frequency or Probability	Severity or Consequence
1	Banana skin lying on the road	2 persons falling on the road out of 100 persons passing per hour. Risk = 2 x 10^{-2} per hour.	1 person gets head injury. 1 person gets leg injury.
2	Broken ladder	4 persons falling from the ladder out of 100 person using it per week. Risk = 4 x 10^{-3} per week.	1 person gets head injury. 1 person gets hand injury. 1 person gets leg injury. 1 person gets waist injury.
3	Running pulley belt without guard	2 workers fingers being trapped out of 30 workers per month. Risk = 2/3 x 10^{-1} = 0.666 x 10^{-1} per week.	1 worker gets crush injury. 1 workers suffers amputation of finger.
4	Platform without railing at height	1 person falling from height out of 1000 persons going there per year. Risk = 1 x 10^{-3} per year.	He dies.
5	Open or loose electric wiring.	1 person getting electric shock out of 10 persons per month. Risk = 1 x 10^{-1} per month.	Heart failure

7.3 Differences affecting Safety performance:

Human factors contributing to accidents are stated in Part 5. They affect safety performance as follows:

(1) Physiological Factors: Physiological human factors are physiological fitness (safe capacity) of an individual estimated from his maximum oxygen uptake capacity, sex, body-build, age, muscular work, posture, clothing, nutrition, training and skill, sickness or disease, environmental heat load (strain), occupational work load and physiological fatigue measured by 'step test'. See Part 2 of Chapter 24 also.

A worker who is physically fit performs well and less susceptible to accidents. Tough task requires more physical (muscular) work, which in turn, demands more oxygen uptake capacity. Test of physical fitness 'is necessary to select a person for accident prevention.

A man can lift more weight than a woman due to sex difference. An adult can lift more weight than a child due to age difference. A man with powerful muscles does more work than that of poor muscular power. A tall man walks faster than a short man. A fat man runs slower than a thin man. Height, body, hands, arms, feet, vision (eyes), hearing (ears) and other postures and traits create individual differences in men and in their performance for safety.

Good nutrition, training and skill increase work capacity and power of performance for safety. Sick man or man with disease has more susceptibility to accidents. High room or process temperature, higher quantity of work and physical fatigue certainly contribute to accidents.

(2) Psychological Factors: Psychological human factors are attitude, aptitude, frustration, conflict, morale, motivation, boredom, monotony, accident proneness, mental capacity and skill, senses, memory, mental fatigue, mental blocks, perception of danger, acceptance of risk, knowledge and responsibility for safety, judgement of mind, impulsiveness, ability to pay attention on machines, tools or hazards, nervousness, fear, carelessness, emotional stability, intelligence, previous experience, vocational interest etc. Difference of these factors in person causes individual differences and affects their work and safety performance. Explanation to some of these factors is already given in foregoing paragraphs. Some more examples of psychological factors are given below:

Sensory motor ability i.e. clumsiness, slowness of motor impulses, defective sense organs, inadequate skill etc. are causative factors for accident. A study of over 600 employees for their sensory motor test, showed that poor test scorers had 48% more accidents than those of high scorers.

Perceptual good ability i.e. to perceive many details of a visual field or to see and understand quickly from a far distance is useful to prevent a person from danger or risk. Harano's research work on drivers proved this fact. If a man cannot see danger or risk while working with chemicals or dangerous machines, he may attract accident. If he understands and accepts the situation as a risk, he will be conscious and more careful, may check safety device or use safety equipment and may avoid accident.

Knowledge (which has no substitute) of unsafe conditions, actions and safe practices makes a man less susceptible to accidents. Information, education and training of safety subjects increase safety knowledge, which helps for safer performance. That is why safety information and training to workers (i.e. their knowledge building) are made statutory under the Factories Act, 1948.

Responsibility creates awareness and sense of duty to perform task given to us. Supervisors, Safety Officers and other responsible persons feel their safety duty to increase their safety performance. There fore policy of promotion to increase responsibility is necessary for better efficiency of work

Emotional instability or maladjustment or more than normal ups and downs in moods may cause more accidents. Such state of mind may result in frustration, conflict, carelessness or negligence ultimately resulting in accident.

Frustration i.e. aggression, regression, unfraindly, withdrawal, imagination, intoxication may make a person accident susceptible. Therefore his level of frustration should be kept under control.

Work experience helps in avoidance of accidents. Vernon and Van Zeits's studies shown that the accident rate was declined due to increase in work experience. New employees are more susceptible to accidents than old (experienced) ones. Higher age adds more experience, wisdom, maturity and stability. Therefore aged employees cause less accident than young ones.

(3) Physical Situational Factors: They are physical workload and stress, working hours, work design, tool and equipment design, hazardous nature and pollution of chemicals i.e. splashes, spillage, gases, dusts, fumes, vapours etc. directly connected with the work, nature of job and ergonomic factors.

If above situations are inconvenient or injurious to health or polluting atmosphere, they may lead to accidents, dangers or risks.

Daily effects of chemicals on workers' health, though it is not termed as an reportable accident (because not resulting in absenteeism), is worse than an accident and certainly needs safety measures.

Awkward position or situation of seat, operating valves, gauges, platforms, tools, equipment etc. cause unnecessary strain on worker's body and may cause accidents. Therefore they should be redesigned to suit the workers (ergonomics) to avoid such accidents.

Long working hours, work without rest intervals, excessive weight, glare or excessive light from welding, dust generating process etc. result in accident. They should be regulated as per the Factories Act.

(4) Environmental Factor's: They are temperature, ventilation, light, noise, vibration, humidity, thermal or nuclear radiation, poor housekeeping etc. and acts 'of God.

It is also experienced that too hot or too cold temperature, high wind velocity, high noise, vibration, darkness, humidity, radiation etc., cause accidents, and good light, colour/music, temperature/ventilation and good housekeeping tend to reduce them.

Psychological Tests: Various psychological tests have been developed and applied to detect above mentioned factors and their correction.

Mental ability test, mechanical ability and related test, psychomotor test, vision test, special aptitude test, personality and interest test, achievement test, merit rating, measurement of training, attitude scales, intelligence or IQ test, skill and manipulative test, trade mill test and computer based assessment methods etc., are described in many books of industrial psychology. Old book of Joseph Tiffin & Ernest McCormick and new book of Lewis Aiken are worth mentioning for such psychological testing and assessment.

To control effects of individual differences, some control techniques are as under:

7.4 Accident Proneness:

This debatable belief is discussed below. 7.4.1 Concept of Accident-proneness

Accident proneness can be defined as a higher than average susceptibility to accident, which arises from psychological factors-and tends to be permanent, if not cured timely.

Old theory of accident proneness or accidents susceptibility is derived from many accident case studies and *Personal Factors* for its causation. Age, sex and experience, emotional instability, physical condition, use of alcohol and attitude toward organisation are main factors. Other factors such as height, weight, eye sight, marital status, number of dependants, distance and method of travel to work, medical history, demotivation, talkativeness, neurotics, smoking, loneliness, less interest, domestic stress, temperament etc., may also provide ground for accident proneness.

Greenwood and Woods presented this premise in 1919 in their paper on Industrial fatigue. It was also supported by some old psychological studies, but their "so called statistical proofs' are criticised as deceptive based on inadequate samples or the result of highly subjective diagnosis. The later studies do not accept this concept of 'accident proneness or accident repeater' and suggest throwing of it.

According to this old concept, some people are so constituted that their very nature (above mentioned personal factors) causes them to bring about accidents and so to injure themselves and others. Such individuals are known as accident-prone or accident susceptible persons. People differ in degree to which they are accident-prone in the same way that they differ with respect to their traits. Accident-prone persons are not necessarily accident repeaters. They may or may not repeat the accident depending upon their learning, experience, training and improvement in health, habits, environment and other personal factors. Accident-prone people do not mean a fixed group responsible for all accidents every .time. Accident proneness is a variable qualitative factor and any man can be accident-prone at any time depending upon personal factor developed in him.

7.4.2 Is it Myth (false belief) or Reality?

C.A. Drake's study in 1940 on accident proneness concluded that the person who reacts quicker than he can perceive is more likely to have accidents than is the person who can perceive quicker than he can react. Farmers & Chambers and Speroff and Kerr also conducted tests but for different jobs.

It should be emphasised that the personal variables that contribute to accident proneness on one job may be unique to that job only. Factor(s) for work situation may differ and it can be identified by specific statistical analysis for that situation.

Many people do not cause any accident for years together. It is a small percentage of accident-prone workers who are responsible for personally caused accidents. This does not mean others do not cause accidents. Proof of this fact is given in a number of studies by Slocomb, Greenwood and Woods, Karl Marbem, Bristol, Snow, Bingham and t)e Silva.

Various tests and clinical approaches are suggested for accident proneness. Such studies have recorded many contributing factors to accident proneness. In addition to personal factors mentioned above, other factors are- inability to concentrate, incapacity to distribute attention, slow reaction time, absentminded-ness, fatigue, reduced energy, inadequate control of reflexes, poor judgement, poor sensory-motor co-ordination, unacceptable behaviour, oscillation of attention, hurry, worry, fear, nervousness, impulsiveness, excitement, eager & enthusiastic, thoughtlessness, overconfidence or any combination of these traits.

Based on above facts and findings, it can be said that accident-proneness is a reality to some extent and not a mere myth. If we call it a myth then what should we call the reality of all above actual human causes and accidents actually happened (and happening) due to them? And accid ent causing by the same persons under the same working conditions where others do not cause any accident? Accident proneness is a name given to a psychological and scientific-study of human behaviour in accident causation.

Viteles mentioned 'circumstances' responsible for more accidents to some persons. Such circumstances could be worry, anger, fear, guilt feeling or other emotional disturbances.

Hale and Hale pointed out that there cannot be any stable personality trait like 'accident proneness'. Some studies revealed that 'members of a study group who sustained a large number of accidents in one period, were not necessarily same who sustained many accidents in a subsequent period.

But it is also a fact that there are persons who have more accidents than other persons in similar situations. However the repeaters are involved in only 15-20 percent of all accidents. Therefore another view prevails telling it a myth. Believers of this view tell that there is nothing like accident-proneness and all accidents are due to working conditions or impersonal factors only and if we can remove all such unsafe conditions there shall be no accident. System safety approach is important in this regard. A man is compelled by conditions to cause mistake or accident and therefore, instead of blaming the human faults or fate; we should concentrate upon to remove the real unsafe condition, situation or environment only. It is true that we must first remove the unsafe conditions, but, what are the reasons that under the same working condition some people make accidents and others not? Can these 'some people making accidents in the same working-conditions' be called accident-prone or not? This replies the question whether accident proneness is a myth or reality.

Dr. Schulzinger and Professor Edwin E Chiselli ruled out the concept of accident-proneness and stress that the proportion of accident-prone people in any group is so negligible as to be quite unimportant in safety work. Professor Edwin says, "The term accident proneness should never be used in safety work or in studies of the causes of accidents and injuries, as it is dangerous, misleading and contributes nothing of practical value to our understanding of industrial accidents and injuries." M.S. Schulzinger's study of 35000 injury cases indicates that the 'injury repeated is not a significant factor in the safety programme.

A leading industrial psychologist Maier says that it is doubtful that a single set of such bio-psychological traits (accident proneness) alone can cause accidents.

Mintz and Blum found that the frequency of repeater injury approximated a pure chance distribution.

7.4.3 A Complex Phenomenon:

Main reason of accident proneness is the individual differences. Nobody wishes accidents, but personal factors do contribute to accidents. Ill health, tension, worry, hurry, lack of concentration and lack of training do cause many accidents. Therefore accident proneness may be regarded as a combination of personal factors, which make a person highly proficient in bringing about accidents. It may be dependent on a rather complex set of traits and these traits need not be the same for all accident-prone individuals. However, if accident-proneness is to have any application to industry, it is necessary to determine the traits, which are associated with accident susceptibility and to develop tests for detecting their presence. Obviously, accidents can be reduced if accident-prone individuals are kept out of hazardous work. In this way the safety of others, as well as that of themselves, will be increased.

Some measures to reduce accident proneness are-

1 Proper selection and placement of employees.
2 Safe-guarding, training and supervision of inexperienced employees.
3 Use of safety and personal protective equipment and
4 Immediate attention to injury and care.

The harm caused by the concept of accident proneness, the new tests overruling this old concept and the real philosophy, are already explained in Part 5 of Chapter-2.

In modern age and modern plants, the concept of accident proneness is hardly accepted. It seems outdated. Modern accident analysis does not accept it and report it Modern safety philosophy puts more stress on detection and removal of unsafe conditions and training for safe actions. However psychologists while studying human failure as an accident cause may refer to such concept.

8. MOTIVATION FOR SAFETY

8.1 Need (Purpose) of Motivation:

Motivation includes inspiration, aspiration, communication, education, participation and training. All these factors are most essential to mould a man to achieve a desired goal in a desired manner. It is a fuel or driving force for all human activities, which should be refined, channelled, rectified, shaped or directed as per requirement. To minimise the human errors or unsafe acts or omissions, motivation helps much and it promotes safety.

If people are not motivated for safety, other efforts will not help much. Even if other measures are taken, motivation is necessary to mould the. people to achieve our goals more speedily and yet safely. Various theories are available for motivating people for work. Periodical feedback to maintain motivation is also necessary.

Our present problem is not of lack of knowledge of safety. The real problem is of implementation of that knowledge, at the shop floor level. This is because of the lack of self-motivation, lack of communication and motivation. People should be made participative by inviting them to say their opinion, reaction or views and guided to act for implementing the safety. Direct communication is more useful than indirect communication. Thus communication and motivation helps in implementing the safety laws.

Formula of Performance = Ability X Motivation, explains basic need of motivation to increase or improve the work performance of individual or group.

Total loss control can be achieved by motivation of employers, employees, trade unions and the Government. Losses of time, money, property and production because of accidents, conflicts etc., must be reduced and that is possible by motivation at all fronts.

8.2 Nature of Motivation:

Motivation is one of the factors that stimulates or influences job performance. A Latin word "mover' means to move. A motive is what moves a person or impels a person. Motivation is concerned with 'Why' and "How' of behaviour.

P,T. Young defined motivation as "the process of arousing action, sustaining the activity in progress and regularising the pattern of activity." .

Steers & Porter and Greenberg & Baron identified 3 major components of motivation:

1. Force or drive to lead to some behaviour.
2. Function to guide behaviour in desired direction and
3. Maintaining or sustaining behaviour once it has occurred.

Herbert Moore says 'To motivate is to cause a release of energy in relation to a desired goal. Effective motivation is determined by three factors: the goal that is to be realised, the energy that is to be released and the tools that are to be used to direct and control that energy. The Whole problem of motivation is the problem of the development of attitudes, loyalties and capacities for making sacrifices toward an entity that is of greater consequence to the individual worker than his job or •his personal welfare.'

Motivation runs top to bottom, therefore the top management and supervisors should be motivated first. Motivation should be self generated, otherwise it should be supplied or induced.

NRF Maier explains motivating as a way of bringing to expression an ability, which a person already possesses. He describes two aspects: subjective and objective. The subjective side is a condition in the individual, which is called a need, a drive or a desire. The objective side is an object outside the individual, which may be called the incentive or goal. When an incentive satisfies the need (as food satisfies hunger or money satisfies economic need), the situation is called motivating. The types of needs and incentives vary from time to time and from person to person. It is an industrial problem to find out needs and their appropriate incentives. This is explained below.

8.3 Theories of Motivation:

Some 'psychological theories are developed to motivate people to improve their performance. These theories are based on varieties of needs and, their satisfaction (incentives or rewards).

8.3.1 Hawthorne Studies (Behavioural Approach):

In an old study conducted at the Hawthorne works of the Western Electric Company, Chicago for 15 years, beginning in 1924, concluded that the attitudes of employees could be significantly changed by the development of a co-operative atmosphere between workers and supervisors.

Change in temperature, humidity, lighting, rest pauses and length of workday have little effect if the employees are well motivated with friendly, social and co-operative relations. Thus motivation has more effect than the improvement in working conditions. If a good confidence is generated in people, they can work hard for their company.

Success of Japanese management seems relied on this theory. Motivated soldiers have won many battles with inferior weapons and being less in number. See part 8.2.4 of Chapter-6.

On power-press machines, workers mostly injure their fingers and get demoralised if the frequency rate is not reduced. Here a supervisor can play an important role by standing near the worker, explaining and training him for pre-start safety •devices, guarding on machine and safe work method, thus giving special attention, co-operation and building confidence in the worker to work accident free.

If workers receive personal touch i.e. special attention for their safety, health and welfare by upper management, they get motivated to give more production even if working conditions like light, space, layout etc. are not fully favourable. This is the abstract of this oldest study.

8.3.2 Maslow's and McGregor's Hierarchy Theory of Human Needs; (Need Satisfaction for Safe Performance)

A.H. Maslow classified the human needs and determined priorities for them. These needs should be satisfied in the following order.

1. **Physiological needs:** Basic or survival needs of food, water, air and rest.

2. **Safety needs:** Protection against danger, threat and deprivation, body and position or status. Reduction of physical and psychological hazards.

3. **Social or Affiliation needs:** Love, affection, friendship, acceptance, association and belongingness.

4. **Ego or Esteem needs:** Two types - (a) Relating to one's self-esteem i.e. needs for self-confidence, achievement, competence and knowledge (b) Relating to one's reputation i.e. needs for status, recognition, appreciation and respect of one's fellows.

5. **Self-fulfilment needs:** Relating to one's own potentialities, for continual self-development or self-actualisation.

This theory helps management to detect needs of their people and to satisfy them priority wise for better or safe performance. Providing safety goggles to welder, grinder etc., giving mask/respirator/hand gloves/aprons etc., to chemical workers and to provide ear plugs to weavers working on high-noise looms, fulfil safety needs of the workers and motivate them for safety. Then after they need love and affection. The steps of this theory can be shown as under:

Human needs → Detection → Satisfaction → Incentive or Reward → Feedback for improved performance → Rethinking of type of satisfaction or incentive, if necessary.

Hierarchy of human needs in this theory can be shown as under:

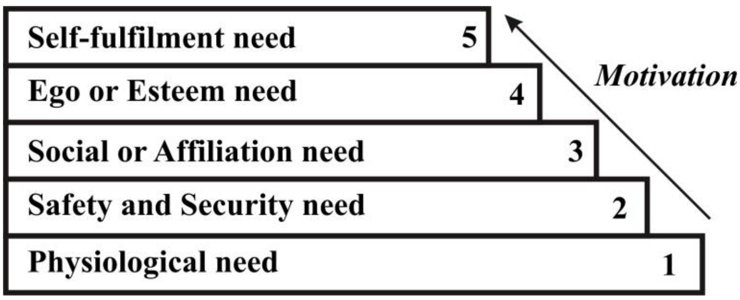


Fig 3.2. Hierarchy of Human Needs

First need should be satisfied first, then second, then third etc. If person is already satisfied with the first need of food, water, rest etc., beginning should be made with the second need and so on.

Maslow's theory was criticised by W. Bridewell, Luthans, Hall & Naligam (1968), Walba & Bridewell and surveys in Japan and European countries raising more questions against such needs and their satisfaction.

However it should be noted that Maslow's research work is some 50 years old and represents priority of needs of that time. Owing to improved standard of living and many changes during last 50 years, priorities have been changed and may continue to change. Effects of liberalization, privatization and globalisation (LPG), decrease in trade union activities and increase in unemployment can bring new challenges and new needs, nevertheless Maslow's needs still seem important and are useful for motivation.

Our Indian concept is to minimise the human needs for real happiness but how to implement it for industrial workers is a psychological problem. Self motivation and satisfaction seems to be the best remedy.

8.3.3 ERG Theory:

Clayton Alderson offered this theory in 1969 based on needs of Existence, Relatedness and Growth (ERG). His theory is an improvement over Maslow's theory.

Existence needs are basic needs of food, clothing, shelter etc., and management can satisfy them by pay, allowances, better working conditions, job security etc.
Relatedness needs are affiliation and esteem needs.

Growth needs are self-actualisation need stated by Maslow.

By knowing needs of the workers if management takes necessary action to feed those needs, the workers can be motivated for better performance.

Suppose some workers do not take part in Safety Committee because of their belief that they know little about industrial safety. If knowing this need of knowledge, they are given proper training for safety; they will be motivated to participate in Safety Committee.

8.3.4 Herzberg's and Myer's Theory

(Motivation - Hygiene Theory):

Frederick Herzberg and his followers - Schwartz, Jenusaitis, Stark and Myers, carried out various studies on motivating factors. Herzberg and his team interviewed 1500 workers for 12 types of investigation to know what were the satisfying factors and what were the dissatisfying factors with their reasons. From this extensive study, some more important factors are given below:

Occupational Group	Satisfiers	Dis-satisfiers
Scientists	Work itself	Responsibility
Engineers	Advancement Work itself	Responsibility, Company Policy and Administration
Supervisors	Advancement Responsibility	Pay

Technicians	Advancement Responsibility	Work itself, Pay
Female assemblers	Supervision	Recognition, Security

Another study points out motivation needs and maintenance needs as follows:

Motivation Needs (Intrinsic Factors) : These are the factors of growth, achievement, responsibility and recognition such as delegation, access to information, freedom to act, atmosphere of approval, merit increases, discretionary awards, profit sharing, company growth, promotions, transfers and rotations, education, memberships, involvement, goal-setting, planning, problem solving, work simplification, performance appraisal, utilised aptitudes, work itself, invention & publication.

An effective intrinsic motivation technique is job enrichment, which includes

1. Making employees responsible for the total function or completion of a task instead of breaking it into assembly line specialisation.
2. Allowing employees to both start and complete a project or task.
3. Diversification of duties so that no one has all of a boring task (there should be interesting parts in all jobs).
4. Delegation-decision making down the hierarchy as much as possible and
5. Conducting rotating job assignments.

Maintenance Needs (Hygiene or Extrinsic or Environmental Factors): These are the factors classified as below

1. **Physical:** Work layout, job demands, work rules, equipment, location, grounds, parking facilities, rest rooms, temperature, ventilation, lighting, noise.

2. **Social:** Work groups, coffee groups, lunch groups, social groups, office parties, ride pools, outings, sports, professional groups, interest groups.

3. **Economic:** Wages and salaries, automatic increases, profit sharing, social security, workmen's compensation, retirement benefit, paid leave, insurance, tuition, discounts.

4. **Security:** Fairness, consistency, reassurance, friendliness, seniority rights, grievance procedure.

5. **Orientation:** Job instruction, work rules, group meetings, shoptalk, newspaper, bulletins, handbooks, letters, bulletin boards.

6. **Status:** Job classification, title, furnishings, location, privileges, relationships, company status.

Neither intrinsic nor extrinsic rewards give a complete motivational package. The factors vary according to person and atmosphere. Therefore selection of proper reward is a tough job.

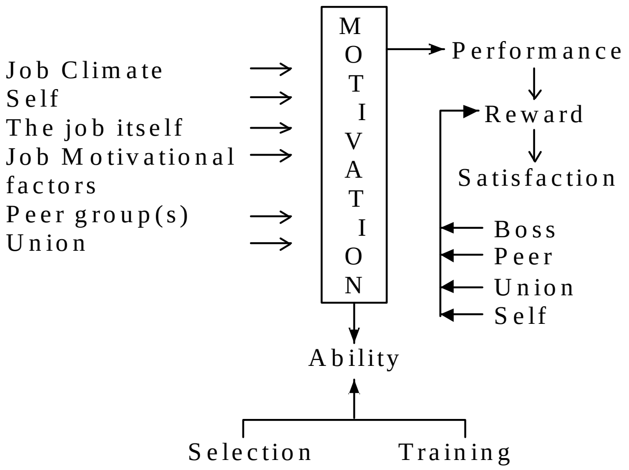
Complete elimination of dis-satisfiers does not give positive satisfaction or motivation. To inspire motivation, satisfiers are to be provided.

To explain and to give (display) in writing safe operating procedure to workers and to provide fixed guard on cutters, fulfil physical needs of the workers. Promoting a Safety Officer on higher post, considering his length of service and performance, fulfils his need of status. Such steps do motivate them.

All top management, supervisors and safety advisors must believe that better psychological working conditions (stated above) can help to improve the life and cooperation of the workers.

8.3.5 Peterson's Behaviour Model (Motivation-Reward-Satisfaction Model):

Peterson has developed a model, of motivation and performance as under-



Here safety performance is dependent upon level of motivation and his ability to perform. Motivation depends on job climate (by boss-style, staff-climate, management-relations), self (personality achievement), the job itself, job motivational factors, his peer group (norms established and performed) and by the union (norms and pressures). Ability depends upon selection (can he do it?) and training (does he know how?).

Following performance there are all kinds of rewards (positive and negative), which influence his level of satisfaction. The' rewards come from the boss, peer groups, union and self. Upon receiving these rewards he then compares the reward received to what he expected to receive and is either satisfied or dissatisfied to a degree, which influences (feed back loop) whether or not he shall be motivated enough to perform again.

8.3.6 Vroom's Valance or Expectancy Theory:

It is also known as 'instrumentality theory or process theory'. Historically it goes back to Tolman (1932), Lewin '(1938) and Peak (1955) but Vroom's version of this .theory introduced it to industrial psychology and that of Porter & Lawer (1968) emphasised on 'How' instead of 'What' of motivation.

Outcomes like salary, security, recognition etc. have different values (attractiveness) for different people. Motivation according to this theory is a product of valance (desire), expectancy and instrumentality.

Valance is the attractiveness of a goal or outcome. It has two propositions: (1) The desire (Valance) for any particular objective (outcome) on the part of an individual is directly related to the likelihood that the objective will in turn lead to other subsequent objectives of given desirability and (2) The greater the valance of any outcome, the more quick is a person to take action.

In Vroom's theory, money acquires valance due to its perceived instrumentality for obtaining other desired outcomes i.e. its power of exchange or purchase.

The abstract of the theory is that the linkage between behaviour and reward should be declared in advance, the linkage should be implemented and reward should be given every time when a desired behaviour is achieved. This looks like a conditional motivation.

For example, if promotion or pay-rise (valance or attractiveness of the goal, outcome or reward) is declared for certain target (desired performance) and if a worker feels it achievable (expectancy perception), he will be motivated to engage in performing to achieve that target. On performance, declared reward should be given to him.

By providing better comfort by ergonomic design of machines, tools, equipment, controls etc., and reward for safety attitude and effort, management can generate desire in workers for safe performance.

8.3.7 Magregor's X & Y theory:

Magregor developed this theory, which has two parts - theory 'X' and theory 'Y'.

Theory 'Y' is more useful to develop safety culture by motivation.

Theory X Normal, conventional or old views regarding human behaviour-		**Theory Y** Modern or correct views regarding human behaviour -	
1.	An average worker has inherent dislike of work and will avoid it if he can.	1.	An average worker does not inherently dislike the work.
2.	An average worker prefers direction, wishes to avoid responsibility, has relatively little ambition and wants security above all.	2.	An average worker learns not only to accept, but also to sick responsibility under proper conditions.
3.	Workers must be corrected, controlled, directed, threatened or punished to achieve objectives.	3.	Self-control and self-directive are preferred by the workers to achieve objectives.

8.3.8 Goal-setting Theory:

Rayon (1970) put more stress on 'intention' to motivate behaviour. Locke & Latham (1990) supported this theory explaining to set goals to motivate people to show their ability (efficiency). Research studies by Miller (1978), Latham & Locke (1979) showed that performance could be improved by setting 'specific goals' and not the general goal like 'do your best'.

Reward for zero accident goal, accident free month, year or department, good housekeeping and a fixed target and guidelines motivate workers to attain them. Goals should not be too easy or too difficult. Moderately difficult goals pose a challenge to an individual and impose the commitment. Steady & Ka/s study (1964) showed that goals, which were perceived as difficult but attainable, led to increased performance than goals, which were easy or impossible to achieve.

Workers should be involved in goal setting process instead of assigning goals by others. Workers' understanding and appreciating of goals are necessary. Latham and Saari's study (1979) showed that it becomes easy to achieve difficult goals through supervisory support. Chhokar and Wallin's study (1984) to improve safety performance showed that 'feedback to workers how to reach the goal' found useful and percentage of workers working with safety precaution was raised from 65% to 95%.

Feedback improves individual as well as group performance. In Britchard, et al (1988) study, group performance showed 75% improvement by group goal setting and feedback. Northcraft, Lee and Lituсy (1990) pointed out two types of feedback - outcome feedback and process feedback. Outcome feedback provides information about consequences of one's actions and process feedback about ways to improve task performance.

Zero accidents goal by NASA (USA) is the best example of this theory. In some Tata Companies, incentives to all workers of a department where no accident occurs during a month, motivated the workers. Supervisors were giving guidance to their workers to achieve the goal for their department.

Summary: Psychological principles discussed in all above theories suggest-various means and ways for management (including supervisors and safety officers) to motivate people for safety and to identify situations leading to conflict, frustration, non-co-operation etc., and techniques to remove them. For further techniques see Chapter-6 on Safety Management.

8.4 Methods of Motivation (Incentives or Rewards) :

While discussing nature of motivation, we have seen that there are human needs, drives or desires (explained by various theories) which- should be satisfied by necessary incentives or rewards for the purpose of motivation. Various methods are available to apply these incentive schemes. Some are given below:

(A) Money as an incentive: Money, in itself has no incentive value. But it can be used to obtain the desired incentives, because of its exchange power or value. Money can satisfy (1) Basic necessities of life (food, shelter, clothes and the like) (2) Necessities for health and education (doctors, choice of foods and so on) (3) Luxuries (mostly acquired needs) (4) Social position and (5) Power. If first need is satisfied men want money for second and so on.

Various methods of pay are applied according to the need or nature of job. Pay in terms of production, time, seniority, need etc., are in practice. Pay in terms of production (work output) is the only method, which utilises pay for motivating all men to produce in accordance with their abilities. But only money cannot satisfy all needs and other methods of motivation are as follows.

(B) Work and Play: Men should learn to play while they are still young, so that this activity can replace work when the latter becomes too strenuous for their energies.

(C) Use of Praise as an incentive: Praise is a form of ego satisfaction, and adults and children can readily be motivated by it.

(D) Competition: It is a motivating factor and highly effective in sports and safety. It can be used in work and it transforms unpleasant work into a game. Competition between equals produces better motivating conditions then competition between unequal in ability.

To promote and maintain safety, various types of safety competitions should be arranged viz., good housekeeping, accident free man-hours worked, production quantity and quality with safe performance, better maintenance of machines, stores, plant and premises, safety slogans, posters, maxims, essays, awards of various kinds etc.

(E) Other Incentives: Among other incentives more important are job security, compensation, opportunities for promotion and advancement, employee financial benefits (insurance and so forth) and informing employees about their job status.

Various studies have been carried out to find out factors of job satisfaction in different occupational groups, by Chant, Wyatt, Berdie, Blum and Russ, Jurgensen and others and many factors (workers' wants) have been recorded. High pay was found to be only at sixth or seventh in importance. Rank positions of such factors that appeal to workers are : opportunity for advancement, steady work, opportunity to use your ideas, opportunity to learn a job, good boss, high pay, opportunity to be of public service, good working companions, comfortable working conditions, good working hours, clean work and easy work. Other factors like benefits, communications and recognition also exist.

Incentives are classified as financial and non-financial, competitive and co-operative. Though money has not lost its importance, non-financial and cooperative incentives are more preferred in these days both in industrial and educational context But for poor people money will remain a powerful incentive forever.

See Part 11.3.5 & 11.3.6 of Chapter-6 for safety competitions and incentive schemes. See Part 8.2.5(2) of Chapter-4 for 10 methods to create and maintain individual interest.

Workers have three types of relations (social system) according to Bray Field and Crockett: (i) with fellow workers (ii) within company structure and (iii) outside the company. Motivation is a function of all these systems.

8.5 Role of Safety Management in Motivation:

Role of Management, Supervisors and Safety Department in motivation is most important. They should adopt following measures:

1. Insist for adequate sensory motor abilities, appropriate muscular perceptual speed or right perceptual style, free from accident proneness, disease and habit of intoxication, appropriate age, sex, experience, work habits and good safety record.

2. By induction training' new workers (including contract workers) should be given necessary safety instruction and training regarding hazards and control measures in industry. This basic knowledge will build confidence.

3. Schedule for above training should be properly designed to include hazards of raw materials and processes, safe operating procedures, safety tools and equipment to be used, safety work permit systems, interpretation of MSDS, labels, signs & signals, rules of transportation, loading and unloading and role of the workers in fire fighting and operation of On-site Emergency Plan.
4. Company's Safety & Health policy. Environment policy and Quality policy should be explained with their objectives and benefits. Organizational interests should be explained. This will bring belongingness and togetherness.

5. Workers should be encouraged to participate in safety committee, safety suggestions and all safety programmes.

6. Accident case studies should be explained at all levels by analysing the different roles in preventing such accidents. See Chapter-30.

7. Motivating thoughts as given in next part 8.8 should be explained with examples. These will help much for motivation.

8. Team spirit and competitiveness should be built-up. This will induct group motivation.

9. Supervisors should take sufficient rounds to them if any unsafe practice is noticed. For good work and follow up of safely rules, they should praise the workers. Safe habits should be cultivated.

10. Proper attention should be paid for basic needs of Health, Safety and Welfare facilities under the Factories Act and Rules for the workers.

Keep good housekeeping, lighting, ventilation and temperature. Avoid overcrowding, faulty arrangement of materials, machines etc. Provide sufficient means of access, right tools and equipment. Prevent leakage, pollution, noise, vibration etc., by good engineering controls.

Excessive workload, working hours, overtime work or work on holidays should be avoided or minimised. Sufficient rest intervals should be given. Statutory provisions shall be followed. This will prevent physical and mental fatigue, frustration, conflict etc.

11. Exploitation of any kind should be avoided. Paying less wages (less than even minimum prescribed by law) to the workers, not paying in time, not paying according to his qualification and experience or reasonable living standard, not paying overtime wages for extra work, requiring regularly to work 12 hours instead of 8 hours in a shift, depriving of holidays, treating unequally among equals/partiality in giving benefits, not implementing any legal order in favour of workers and indirect harassment to leave job are some instances of exploitation. Top management should leave 'them if it desires motivated workforce for better performance.

12. Supervisors should recommend or the top management should take timely decision to give increment, promotion and other monetary benefits to the workers.

13. Job rotation or job enrichment should be practised as a technique of motivation as 'explained in Herzberg's theory. It should include proper job distribution, job simplification and job satisfaction.

14. Introduce change in job if monotony is observed. Make the job meaningful to develop interest in it. Take workers in confidence to fulfil goals. Provide welfare and recreational facilities. Give responsibility and reduce interruption of work. Use colour and music where appropriate. Consult psychologist for special psychological measures to increase worker's interest and .efficiency by change in their behaviour.

15. Insist for man-machine matching i.e. designing machines, tools, equipment, controls and situations most convenient to people at work. This can reduce accidents. See Part 3 of Chapter24 for details.

16. Opportunity of advancement for R&D work, new product, new market, new safety device, diversification and delegation of more powers should be given to the deserving workers.

17. Bureaucratic or dictatorial behaviour retards motivation. Therefore middle and to management should be cautioned for this negative factor and they should be instructed to observe flexibility, love, affection, sympathy an good respect to workers.

18. Annual work assessment report (as CR in Govt for individual employee should not be written with any bias or by misusing the power. This will certainly de-motivate the worker. It should be transparent with opportunity for justification for not meeting any target. It should have guidance how to improve upon.

These are general measures. A company should add more measures specific to its requirement or based on any psychological study carried out in the industry.

8.6 Motivating Thoughts:

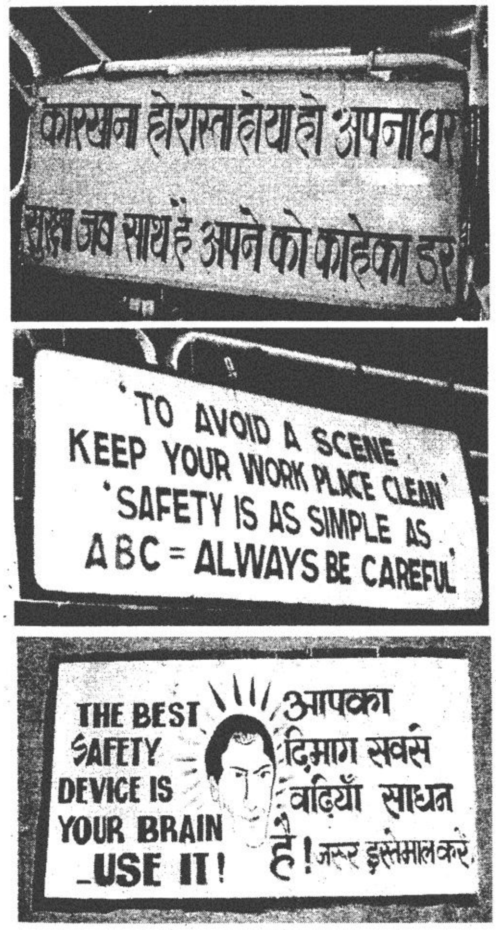


Fig 3.3 Display such Motivating Thoughts

It is said that 'it is not the gun that fires, it i the heart of iron which fires the gun'. After all it is the heart (**with mind**) full of confidence, courage am motivation that drives a man to achieve the goal.

Motivating thoughts or ideas play an important role in this regard. No motivation is possible if human mind is not appealed by inspiring thought. This is true in case of safety motivation also.

We have to motivate workers to work safely and without accident. Therefore it should be impressively brought to their mind that any accident will cause ham to them only and therefore any accident prevention work is in their interest. Some thoughts are given below as an example. Many such thoughts may be developed based on experience and need of time and situation

(1) All are losing by Accidents:

By working in factories, a finger is cut, eye lost, hearing damaged; skin, lungs, stomach deteriorated or cancer contracted, then who is benefited?... Nobody.

Life lost in accident or life span reduced due to pollution, then, who is benefited?... Nobody.

Nobody is ever benefited by any accident. Everybody loses only. The worker suffers pain and aftereffects, loses money in transport, medicine and dispensary expenses. His family members suffer pain and lose time to serve him. Everything is lost of a family whose main person loses life in accident. The deceased cannot be brought back by compensation. Original spare-parts of human body are not available in the market

Fig 3.4 Human body parts are not available in market

The employer loses the benefit of an experienced (trained) person, has to pay compensation in court and incur other expenditure including, medical and transport charges. Time is lost in investigating the accident and repairing the machine if damaged. Production is interrupted and no such skilled worker can be prepared in a short time.

If the deceased is a social worker, society and nation both lose his services. In totality everybody is losing and nobody is gaining by accident. Therefore friends! Do determine from now to stop accident by all means.

(2) Accident causes more Harm to the Worker:

First victim of any accident is worker himself, because he is nearer to the place of accident. Who is exposed to gas or leakage? Worker only. Who hurt by falling, slipping or striking? Worker only. Who hurt by a falling body ? Worker only.

Paying fine or compensation in court may relieve an employer, but can an injured worker be relieved from pain and suffering? No. Can his family get his support if he is died? No.

Thus it is the worker only who loses more by accident. Therefore we have to think of our safety first.

(3) Foolishness:

To provide guard after cutting of fingers, to cause fire and then to extinguish, to discharge gases and then to search mask, to invite emergency and then to rush for control measures... Is it not foolishness?

Therefore, awake, arise and remove all unsafe working conditions and actions first.

(4) Worse than an Accident:

Every year some 2 lakhs people die in accidents in our country. Many more are injured. But the most serious matter is that by inhaling polluted air, we are calling death gradually near and near.

Is it not surprising that this condition of working in polluted air is not called 'accident' because immediate absenteeism of 48 hours is not noticed thereby?

It is always advisable to consider this condition worse than an accident and try to remove it.

(5) Five years deducted from life! :

Whatsoever pay-rise and facilities we may obtain, but, if we continue to inhale polluted air, at the time of retirement, with gratuity, we will certainly get a certificate from the nature- *'Five years are deducted from your life'.*

Do you wish this?

If not, awake and build a wall before the water comes. Do whatever you can do to prevent pollution.

(6) Nothing is costlier than Life:

Everybody loves own life because everything can be experienced till the life is live. Future after life is unknown. All fruits of this world can be enjoyed only until the eyes are open and live. .Therefore nothing is costlier than life. Then why should we lose it by our own mistake? Therefore firmly determine not to commit and mistake to cause an accident to oneself or others.

(7) Safety must be our Way of Life:

Safety motivation must last lifetime. Temporary determination due to any emotional setback or funeral asceticism (smashan-vaimgya) will not last long. Safety attitude must become a habit or part of life. Whenever we see and wherever we see, we must see through the safety-eyes. Our thinking, observing, working or supervising at the workplace, home or anywhere else, must be with safety-eye, safety-outlook, safety attitude and safe behaviour in all respects. Safety cannot be confined with any workplace or any time limit. It has to be with us till we live and enjoy. Therefore it must be our way of life.

(8) Safety needs Active Participation :

Safety begins with our selves. 'Others will practise safety, it is their duty, why should I worry?' is an improper thinking. Safety needs our participation too, because our mistake can contribute to an accident even if everything is all right. And if we do not participate, how can we expect others to participate? Therefore safety needs' our active participation first. Participate yourself in safety and let others encourage or inspire to follow you. This is the only best way of safe behaviour.

(9) Implement, Implement & Implement:

No safety slogan, safety notice or "safety literature, including such books, will save life unless it is practised. Therefore, implement what you know or learn from safety literature.

Don't wait till any accident takes place. Think and prevent the possibility of accident causes. implement all safety measures.

There may be a thin boundary between what is safe and what is unsafe, what is legal and what is not legal. Identify this boundary and implement preventive measures to remain within a safe limit.

(10) Protect the Environment:

Man is born of food,
Food is of plants,
Plants are of earth,

Earth is of water,
Water is of air,
Air is of space and
Space is of God.

One, who ignores this togetherness of life, perishes. Therefore Protect the Air, Water, Earth and Plants - all elements of the God. They will protect you.

(11) Killing of Nature means killing of Self:

gRok p izd`fre~ ,"kke~ vkReuk'ka dfj";fl A
rnk tkxzra Hkks iq:"k% la;E; ro izo`fRre~ AA

By killing, polluting and distorting {he Nature and its Vicinity, are not committing Suicide ? So, O Man, 'Be aware and restrict such wrong practices.

(12) Work of Safety People is Invisible:

Accidents, injuries and losses that take place are visible but those prevented are invisible. By the constant efforts of safety people, hundreds and thousands of possibilities or events of accidents are prevented. This work is neither visible nor measurable. Cost of such prevented accidents and losses is uncountable. Its value is the highest. The work of safety people should be evaluated and assessed in this way.

(13) Safety pledge

"On this day, I solemnly affirm that I will rededicate myself to the cause of safety, health, and protection of environment and will do my best to observe rules, regulations and procedures and develop attitudes and habits conducive for achieving these objectives.

I fully realize that accidents and diseases are a drain on the national economy and may lead to injuries, disablements, deaths, harm to health, damage to- property, social suffering and general degradation of environment.

I will do everything possible for the prevention of accidents and occupational diseases and protection of environment in the interest of self, family, community, organization and the nation at large."

9. BEHAVIOUR BASED SAFETY (BBS)

This is a psychological approach to improve human behaviour for the purpose of reducing accidents.

9.1 Criteria and Strategies:

Psychological concept of 'behavioural safety' or behaviour based safety (BBS) was studied and applied during the years 1968 to 1972 by Aurbrey Daniels, Wanda Myers and others. The research continued and studies during last 15 years showed good results that by observing and changing behaviours of the workers (motivation), accidents can be reduced significantly.

In Hawthorne studies (Part 8.3.1) it was found that 'behavioural approach' was giving good results (accident reduction) than the changes in effects of working conditions like lighting, working hours, rest interval etc. This is die base of BBS concept.

In BBS approach, 'safe behaviours' are targeted, decided and explained to the workers. Then performance of these behaviours is observed. It is also called performance management. Feedback is obtained and reduction in accident rate is measured.

Sometimes a 'design team' is formed by selecting shop-floor workers including representative of supervision and safety department. This team decides following steps:

1. How to observe unsafe practices or acts and to design observation criteria for this.
2. Coaching process to give brief guidelines to improve safety -behaviours to eliminate or reduce those unsafe acts.
3. Plan to use data of observations regarding unsafe acts.
4. Plan to support the process of improvement (motivation for target).
5. Plan training if still required.
6. Plan for maintaining the process.

Thus by such systemic planning, behavioural psychology is used to promote safety at work. BBS approach proceeds as under:

1. Observing unsafe behaviours or acts of the workers in the organisation and collecting then data.
2. Defining a set of model behaviours to reduce the unsafe acts..
3. To give short duration training to workers regarding their unsafe acts, management observations and explaining safe (model) behaviours.
4. Observing new (improved) behaviours and recording their consistency and frequency.
5. Getting feedback and supporting new behaviours.
6. Data collected is used for recognition, problem solving and continuous improvement.

9.2 Management Techniques:

Management control for implementing above BBS concept includes following techniques:

1. Design team of selected workers to record observations, develop support materials and provide training.
2. Identify elements or targets and decide steps to focus on each of them.
3. Organise a full day meeting instead of one or two hours meeting to plan the process after full discussion.
4. Design own steps instead of copying the same from other companies.
5. Do not waste time to complete training of all the workers. Start implementation after training some 20% workers and continue training for others. Thus the time cycle will begin soon to observe the result.
6. Avoid unnecessary training of team members. Those who are already trained need not require training.

E X E R C I S E

1. Comment on the following statements by giving your opinion:

1. 'Human behaviour' is at the top in any accident prevention work.
2. Psychological safety factors are vauge and are of no importance.
3. It is the 'mind' of the man only which is the main driving force of any safety „ activity. Utilize it for safety. .
4. "Every major management problem is in part psychological" - Ordway Tead.
5. Self-discipline is the best remedy for unsafe acts.
6. Proper attitude toward safety is the first requirement.
7. Frustration increases accident rate. .
8. Conflict has no place in safety activity.
9. Individual differences always exist. They are to be reconciled for the purpose of safety.
10. Accident proneness is reality. It cannot be removed.
11. Accident proneness is a vague concept and absurdity. It must be thrown out.
12. 'Psychology lies at the root of sequence of accident causes' - H.W. Heinrich.
13. Every employee is a problem employee.
14. "Motivation is a release of energy toward a desired goal" - Herbert Moore.
15. Psychological factors were found more effective than the working conditions in Hawthorne studies to reduce accidents.
16. Moslow's hierarchy theory of human needs is outdated now-a-days.
17. Motivational factors for safe attitude are difficult to judge. Which should be adopted?
18. Safety Management has many roles to play in motivating workers for safety. Which are these roles?
19. All are losing and nobody is benefited by any accident.
20. Accident causes more harm to the worker himself.
21. Nature's Certificate - "Five years have been deducted from your life" if we continue to work in polluted atmosphere.
22. 'Behaviour based safety' is a good modern concept but how to. implement?

2. Write Short Note or Explain in brief:

1. Need of safety psychology.
2. Industrial psychology.
3. Definition of 'safety psychology'.
4. Employer's psychological problems OR Employee's psychological problems.
5. Accident causative factors.
6. Corrective measures to reduce frustration OR Conflict in industry.
7. Morale- its importance for safety.
8. Difference between fatigue and boredom.
9. The problem employee.
10. Accident proneness.
11. Need of motivation for safety.
12. ERG theory OR Goal setting theory.
13. Methods of job climate improvement.
14. Importance of motivating thoughts and their display.
15. Safety must be our way of life.
16. Concept of Behaviour Based Safety (BBS).

3. Discuss with details:

1. Human factors contributing to accidents.
2. Role of Safety Management in Motivation.
3. Hawthorne studies of behavioural approach or Mashlow's Theory of human needs.
4. Methods of motivation.
5. BBS techniques for accident control.

Reference and Recommended Reading

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4. Influence of Psychology in Industry, by *Dr. B.K. Roy Chowdhury*, Metropolitan Book Co., New Delhi.
5. Industrial Accident Prevention, by *H.W. Heinrich*, McGraw-Hill
6. 'Surakshit Kamdar' by Dr. K. U. Mistry, Siddarth Prakashan, Ahmedabad-380014
7. Human Factors Engineering by McCormick E.J., McGraw-Hill, New York.
8. Safety Thoughts by Loss Prevention Association of India Ltd.
9. Human Safety and Risk Management by Ian Glendon, Sharon Clarke and Eugene McKenna.
10. Safety Management, A Human Approach by Dan Petersen.
11. Keeys to Behavior-Based Safety by Featuring E. Scott Geller.
12. The Values-Based Safety Process : Improving Your Safety Culture with Behavior-Based Safety by Kimberly Ann Rogers and Duncan Chappell

CHAPTER – 4

Accident Causation and Prevention

THEME

1. CAUSATION OR OCCURRENCE?

The term Accident Causation is preferred against 'Accident Occurrence' because of the safety philosophy that 'Accidents do not occur, they are caused'.

Most of the accidents are caused by our latent or patent, visible or invisible, known or unknown, detectable or undetectable, intentional or unintentional unsafe acts, conditions and sequential events leading to accident. They explain rather the causation and not just the occurrence. Therefore all safety people should find the 'cause' of accident and the appropriate measures for prevention.

The word **'causation'** points out 'our responsibility' to find out cause and preventive measures to remove real reasons causing that accident. The word 'occurrence' points out occurring by chance or fate or something else and indicates nobody's responsibility, which is not the healthy or safe philosophy of safety.

1S:3786 gives seven factors relating to causation of accidents : agency, unsafe mechanical or physical condition, unsafe act,-unsafe personal factor, type of accident, nature of injury and location of injury.

The terminology and philosophy given in Chapter 2 and 3 must be studied before reading any chapter including this one.

2 THE ACCIDENT PROBLEM

The zero accident goal is an ideal goal, and one must try to achieve it by using all safety philosophy and technology. In reality, an industry and accidents are co-related and each industry is facing the accident problem, the nature, number and size may differ.

Nature and Size of the Problem:

It is this accident problem at the root which has generated the need of safety. Deaths, injuries and suffering are its direct results. Compensation, production-loss, time-loss and various costs-losses are indirect results. The injured worker, his family, factory and the nation, all are the sufferers. Accidents not resulting in human injuries, but resulting in property damage or money-loss are also accountable and undesired. Therefore accident is always undesirable. That is why the accident problem has attracted attention worldwide.

Many employers look at it leniently and do not pay proper attention. They feel- that it is cheaper to prolong the hazard than to remove it. Because of the insurance schemes and ESI Act, many employers think that now they should not worry because they have insured their plants and workers against accident and they will be compensated. Such attitude increases the accident-problem and acts against the efforts for safety.

Many workers also tend to take advantage of the ESI Scheme and cause deliberate accidents. This has increased the number of reportable accidents, which can be reduced by the motivation of Workers and then unions. The national money-loss and time-loss by such accidents must be prevented by co-ordinated efforts. Training at all levels helps much in this regard.

The size (severity) of this accident problem can be judged from the (1) Cost of the accidents and (2) Statistics of accidents which are explained in Chapter5 to discuss its various aspects. Yet, some highlights are given below:

In India during 1994 there were total 190435 accidental deaths recorded, out of which the figure in factories was 606 (For other causes see tables in Chapter-5). Total injuries (fatal and non-fatal accidents) during 1982 and 1983 were 296027 and 213160 respectively. This figure in 1990 and 1991 was 128117 and 60599 respectively. This indicates decrease in accidents despite increasing industrialisation and employment. This is owing to non-reporting of accidents from many states. See Part-2 of Chapter-5 for such inadequacy of data. Yearly ©6000 fatal and 6 lakhs reportable injuries are estimated in factories of our country.

The accident-tall in factories of the Gujarat State is also given in Tables of Chapter-5.

Similarly figures for accident compensation and expenditure can be obtained from all insurance companies, ESIC authorities, hospitals, dispensaries and other sources to understand the accident problem from all sides. Some 50 crores rupees are estimated as national cost of injuries per year.

The accidents are classified industry-wise and causation-wise. Such classification and breakup are explained in Part 3.5 and 3.6 of Chapter-19. See also Table 5.22 of Chapter-5.

Besides human injuries, there are property damage .(no injury) accidents, which are 10 to 20 times higher than the first-aid accidents.

Non-reporting and under reporting of accidents (including occupational diseases), make this problem more severe. Reported figures are quite inadequate.

The accident problem emphasises the need for safety and accident prevention techniques, which are discussed below.

3. NEED FOR SAFETY

Much is said and can be said for the need of safety. Everybody recognises its need. A few factors are given below:

1. Industries are increasing to fulfil basic human needs food, clothing, home, employment or earning and requirements of goods, services and facilities. This brings industrial hazards of various types viz. mechanical, electrical, noise, vibration, chemical (fire, explosion, radiation, gas, dust, fumes, poisoning etc.) and many visible or invisible health hazards. It is the basic need to protect the human life and environment from all such hazards. Only safety can do it.

2. Direct and indirect costs of accidents are tremendously increasing and causing the great national loss. This can be prevented by safety (see Part 4, Chapter - 5).

3. Workers are our national wealth. We cannot afford to lose them. Fatal accidents must be minimised to prevent this fatal loss.

4. Deaths and injuries extend suffering to the families and society also. This must be prevented or curtailed by safety.

5. Social loss in the form of pain, loss of earning capacity, loss of life or limb, ill-effects to health, diseases, increase of handicapped persons, increase of court cases and emotional losses due to accidents must be reduced by safe conditions, safe practices-and training for them.

6. Productivity is linked with safely. Increasing and maintaining safety gives good productivity.

7. Humanitarian, legal, social and economic reasons for accident prevention are also true for the need of safety. They are explained below.

Based on above requirement, it can be said that 'AS place of industry in society is inevitable, place of safety in industry is also inevitable. As industry is useful to society, safety is useful to industry.

4. REASONS FOR ACCIDENT PREVENTION

Five main reasons for accident prevention are stated below and shown in Fig. 4.1.

Fig. 4.1 : Reasons for Accident Prevention

4.1 Humanitarian or Basic Need for Safety:

The vedic philosophy that a man should protect man is the fundamental or basic reason for accident prevention. Employers should protect their workers by providing good working conditions, safety equipment and training. It is their humanitarian or moral or basic duly under the common law. Similarly the employees should also protect themselves and their fellow employees and surrounding, by their safety duty, precautions and safe practices. Protection of self and others is the primary duty of every person from humanitarian point of view. Our Hindu culture thinks of protection of birds, animals and all living creature far beyond the human protection.

To minimise deaths and injuries, pain and social suffering is the basic need for accident prevention.

For any industrial activity five 'M's are required
Manpower,
Money,
Material (includes machinery),
Management, and
Market.

Out of these, only manpower is a live element and others are dead, functional and operated by men. All other factors are for men only. Management and market cannot function without men. Money and material cannot flow without men. Machinery cannot be designed, operated and maintained without men. Thus **'man'** is predominant and most important factor in all industrial activities. Prevention of accident to 'man' is. 'therefore most essential. It is humanitarian.

4.2 Economic or Costs of Accidents:

There are three agencies that suffer economic losses due to accidents:

1 Worker and his family.
2 Management.
3 Society and nation.

Worker & his family suffer economic losses clue to loss of life or limb, loss of earning capacity and extra expenses viz. medical, nutrition, transport etc. Emotional and mental suffering is extra loss.

Management sustains money loss due to direct (insured) and indirect (uninsured) costs of accidents (For details see Part 4 of Chapter-5). The above costs added together give the total cost to the organisation. The top management should consider cost benefit analysis and adopt cost effective safety measures to reduce such costs, pain and suffering.

Prevention or reduction in accident cost is direct benefit to the company. Investment for safety should be considered always necessary.

4.3 Social:

Society is benefited by help from the men and goods, services and production from the men.

Injury or death of a worker is not an individual loss but directly and indirectly it is a loss to the society also because a man does not live in isolation. He is connected with society and has many relations in many directions. Therefore loss of a person is loss to the society by way of his usefulness to the society.

4.4 Legal:

Legal reasons for accident prevention are due to laws framed by the Government

It is the statutory duty of occupiers under the Factories Act 1948 and other Acts to provide safe conditions for the prevention of accidents and protection of workers. Breach of law may .result in prosecution, fine, punishment and adverse publicity. Heavy penalty and compulsory imprisonment are provided for breach of certain safety provisions resulting in death or serious bodily injury. Enhanced penalty is prescribed for repeated offence. The court can pass an order for compliance also. The inspector has power to issue an order to require safety measures before a specified date or to prohibit to run the factory till the compliance is carried out. Thus legal reason for accident prevention is strictly set out for the employers, and is supported by the Courts' judgements.

The statutory duty is imposed upon employees also to observe safety rules, maintain safety guards and conditions, and to use safety equipment so as not to injure self and others.

In democracy, everybody suppose to know and follow the law. of the land.

4.5 Productivity:

'Safety increases productivity,' needs to be understood.

Peter Drucker defines productivity as "the balance between all factors of production that will give the greatest output for the smallest effort (input)". It is maximum when highest output is obtained with minimum expenses of resources and when resources are not used in the most economical manner.

Productivity requires elimination of loss in all forms viz. losses of men, materials, machine, manufacturing process, products, money, time etc. It covers many factors from design to disposal level. Safety maintenance for accident prevention reduces such losses, cuts accident costs and helps directly in increasing productivity. The employers must recognise this fact and must invest sufficient money for accident prevention and reduction programmes, which will save money, time and injury losses due to accidents and increase their productivity and profit.

Thus a safe way is the best way and safety is a key to productivity. It is also said that safety and productivity go hand in hand or they are two sides of a coin.

Thus safety and productivity are equally important and help each other. However in practice, many times production people consider safety as an obstruction or brake to their work and require workers to go ahead by any means to meet production target. Such attitude may result in accident which will retard productivity.

5. FACTORS IMPEDING SAFETY

The factors impeding i.e. retarding or injuring safety are those factors, which go against the efforts for safety. It is necessary to identify such negative factors (as they cause hazards) and to remove them for the purpose of safety.

A list of such factors may be very long and may vary 'from factory to factory. Some common factors are classified and given below:

5.1 At the Management Level:

1. Passive interest in safety by the management. No safety policy.
2. Compromising with safety for production.
3. Poor maintenance of machines and equipment.
4. Poor working conditions or not providing proper lighting and ventilation, safety guards, devices and equipment.
5. Ageing or corrosion of the machines, plant and buildings.
6. Improper location and layout of plant, building, machinery and equipment.
7. Improper design or selection of tools, machines, materials, vessels, equipment and products.
8. Improper methods, procedures or use. of raw materials, machines, equipment etc. in storage and manufacturing process.
9. Lack of inspection, supervision and training for safely.
10. Absence of safety organisation for proper and continuous attention on safety.
11. Lack of awareness and insistence for safety.
12. Improper selection or placement of men, machines, methods, tools, equipment etc.
13. Lack of motivation and participation for safety.
14. Poor infrastructure of the organisation.
15. Poor financial condition of the organisation or not providing sufficient safety budget.
16. No written rules for job description, procedure and safe production.
17. Lack of safety aspects in accident prevention.
18. Frequent changes in shifts, working hours and calling workers for overtime work or on holiday etc.

5.2 At the Workers Level:

1. Passive interest in safety by workers. No or less participation in safety programmes including safety committee.
2. Insufficient knowledge, qualification and training for the job.
3. Reluctant to use PPE and other safety equipment.
4. Not maintaining the machine guards, safety devices, equipment etc.
5. Misuse of guards, safety devices, protective equipment etc.
6. Indiscipline, laziness, disobedience for safety rules for whatsoever reasons.
7. Non co-operation to the management to carry out regular as well as emergency safety duty for safe close down or safe running of the plant and processes to avoid accidents.
8. Guided by personal (psychological) factors causing unsafe actions.
9. Poor socio-economic status, financial hardship, family problems, worries, tensions etc.
10. Improper attention or judgement on the matters of safety.

5.3 At the Government Level:

1. Not enacting or amending requisite safety laws and poor or non-implementation of the enacted safety laws.
2. Poor or no incentives, awards, rewards, programmes, subsidy, rebates, text benefits and encouragement to employers and employees for their safety efforts.

6. BASIC TERMS IN ACCIDENT PREVENTION

See Part 3 "Safety Terminology" of Chapter-2 for the definitions of terms. The words - accident, accident prevention, damage, danger, hazard, injury, loss control and prevention, risk, safety, unsafe act, unsafe conditions etc., are defied therein.

The basic terms directly connected with **accident causation** are discussed below:

6.1 Incident:

See part 3.43, Chapter -2 for definition.

For accident phenomenon, it indicates event that results in accident.

6.2 Accident:

See Part 3.1 of Chapter 2 for definitions and philosophy.

It is an undesired-or unintentional event that results in physical harm to a person or damage to property or environment. It is usually the result of a contact with a source of energy (mechanical, electrical, thermal, chemical, etc) above the threshold limit of the body or structure.

The term *physical harm* in above definition includes injury, death, disease and adverse mental, neurological or systemic effects resulting from an exposure or circumstances encountered in the course of employment.

Heinrich's definition of an accident is "An unplanned and uncontrolled event in which the action or reaction of an object, substance, person, or radiation results in personal injury or the probability thereof". Like a mathematical theorem he concludes:

1. A personal injury occurs only as the result of an accident.
2. An accident occurs only as the result of a personal or mechanical hazard.
3. Personal and mechanical hazards exist only because of the faults of persons.
4. Faults of persons are inherited or acquired by environment.

This theorem points out personal fault (unsafe act) as the root of any accident A person designs, manufacturers, operates and maintains a machine, equipment, plant etc. His fault (error or mistake) lying anywhere from design stage to maintenance stage may cause an accident which results in injury.

An 'accident' is also defined as "An unplanned and unexpected event which causes or is likely to cause an injury".

An 'accident' is the result of carelessness, casualness or any fault known or unknown. This points out that carelessness and casualness (taking thing lightly) or any hidden fault can cause an accident.

Sachman defined in 1961, accident as an event which is unexpected, unavoidable and unintended. However other researchers of accident causation analysis say that most of the accidents are avoidable or preventable. This concept emphasises the need and importance of control technology to minimise the accidents.

'Accident' as defined by 'Accident Facts, NSC, USA' in their 1997 edition, is that occurrence in a sequence of events which produces unintended injury, death or property damage. Accident refers to the event, not the result of the event, while unintentional injury refers to the result of an accident and is the preferred term for accidental injury.

It is also defined as "An unplanned or unintended occurrence that interrupts or interferes with a work activity". This definition is based on the fact that many accidents, the great majority, yield no injury and receive passing attention only.

Thus there may or may not be any injury to person or property, the only symptom of an accident is 'interruption or interference with a work activity or energy transfer'. This is the broad definition, giving rise to the concepts of 'Damage accident', 'Lost-time accident', 'Total loss control' and 'Total loss prevention'.

Nowadays we see 'planned or intended accident' also, but, then they may fall under the Indian Penal Code as offences against person or property.

Primarily, in industry, an accident is considered as (in unplanned or unexpected event resulting in injury to a person or property or both. Damage accidents (without human injury) are secondary. Statutorily some damage accidents (dangerous occurrences) are reportable under the Factories Act, 1948.

The word 'accident' as defined by Indian Standard: 3786 - 1983 means an unintended occurrence arising out of and in the course of employment of a person resulting in injury.

For the purposes of the Workmen's Compensation Act 1923, 'a personal injury caused to a workman by accident arising out of and in course of his employment is said eligible for compensation depending upon the types of injuries listed in Schedule-I and the occupational diseases in Schedule- III of the Act.

The word accident is not defined in the Factories Act. Its reporting is defined as follows (Section 88).

Notice of certain accident: where in any factory an accident occurs which causes death, or which causes any bodily injury by reason of which the person injured is prevented from working, for a period of forty-eight hours or more immediately following the accident/or which is of such nature as may be prescribed in this behalf, the manager of the factory shall send notice thereof to such authorities/and in such form and within such time, as may be prescribed.

Report of accident to a person or animal is also required under the Electricity Act and Rules.

Thus the pure or theoretical definition of 'Accident' includes 'event' but not necessarily its result as injury or damage. In this context, it is as good as 'near-miss' and accident may or may not have injury. The legal or practical definition of 'accident' includes both 'event' and 'injury' otherwise it is not an accident.

'Accident' prescribed under Rule 103 of the Gujarat Factories Rules, considers 'injury'. It also prescribes 'dangerous occurrences' which may or may not include personal injury.

An accident sequence and consequence are explained in Part 7.1 following.

6.3 Injury:

To injure means 'to hurt' and an injury means 'a harm'. In legal terms injury may be to a person or property or both and compensation (damages) can be awarded to the injured person for the loss he has suffered and may continue to suffer. Punitive damages can be awarded for grave injury.

An injury could be **psychological** also and not necessarily a physical condition resulting from a mechanical, electrical, chemical or radiological accident. A heart attack resulted from unusual mental stress from the work is injury for which compensation is payable. But natural death or heart attack during normal activities may not be considered as an injury from accident.

Injuries are not considered resulting from an accident where wilful death, self-inflicted intentional injury, intoxication and undue alteration by the person injured are involved.

There are two types of injuries. Minor injury generally means that having no permanent effect and leading to less than three days off work. Major injury generally means that leading to more than three days off work. The major injury may be fatal (death) or serious. A fatal injury is a great loss to the worker, his family society and the employer.

An **injury** is an external damage to the human body, disturbance or dysfunction resulted from an accident.

By **cause**, injuries may be mechanical (bruise, cuts, tissue ruptures, breakage etc.), thermal (shock, burn, frost-bite), chemical (bum, acute intoxication and poisoning), radiated (tissue regeneration, changes in the haematopoietic system), or combined (the effect of more than one causative factor with various consequences). The result of accidents (which may cause serious, minor or no injury) may be temporary or permanent disablement or a fatality (injury).

The term **"accidental injury"** denotes an injury to a workman due to an accident. It does not include an injury to a worker's health unless it results directly from an accident, as for example, a poisoning due to toxic chemical.

"Serious bodily injury" as defined in section 92 of the Factories Act means "An injury which involves, or in all probability will involve, the permanent loss of the use of, or permanent injury to, any limb or the permanent loss of, or injury to, sight or hearing, or the fracture of any bone, but shall not include, the fracture of bone or joint (not being fracture of more than one bone or joint) of any phalanxes of the hand or foot".

An injury is merely the result of an accident: An accident is controllable, but, when it occurs, it is difficult to control the resulting injury. The severity of accident depends upon the material causing injury, energy released, body part being injured and the physical or mental condition of the person being injured. As accident precedes injury, attention should be paid to prevent the accident.

H.W. Heinrich estimates that in a unit group of 330 accidents of the same kind and involving the same person, considering average of averages, 300 result in no injuries, 29 in minor injuries and I in a major lost-time injury. It indicates **an ample opportunity to prevent any injury** by efforts during 300 no-injury or warning accidents. This foundation of a major injury is shown in Fig. 4.2.

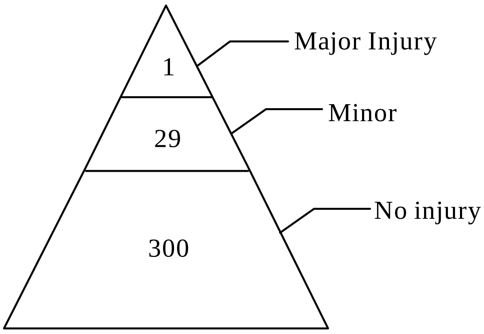


Fig. 4.2 : Foundation of a major injury

See Part 7.1 for further discussion on this ratio theory.

6.4 Dangerous Occurrences:

U/s 88A of the Factories Act and u/r 103 of the Gujarat Factories Rules, the following occurrences are prescribed as dangerous and they are reportable in Form No. 21 (for bodily injury or death) & 21A (for no bodily injury, property damage may or may not be resulted):

1. Bursting of a steam plant under pressure.
2. Collapse or failure of lifting appliances or overturning of a crane.
3. Fire, explosion, escape of molten metal, hot liquor, gas etc.
4. Explosion of a pressure vessel.
5. Collapse or subsidence of a structure.

6.5 Dangerous Operations:

The term 'dangerous operation' is used in section 87 of the Factories Act meaning 'Any manufacturing process or operation carried on in a factory exposing any person employed in it to a serious risk of bodily injury, poisoning or disease' and the State Government is advised to make rules regarding dangerous operations.

Rule 102 of the Gujarat Factories Rules lists 27 Schedules of such dangerous operations.

The details of all above schedules suggest preventive measures for serious risk of bodily injury, poisoning or occupational diseases. They must be thoroughly studied and implemented.

6.6 Hazardous Processes & Industries :

Section 2(cb) of the Factories Act, 1948 .defines 'hazardous process' as follows:

"Hazardous process" means any process or activity in relation to an industry specified in the First Schedule where, unless special care is taken, raw materials used therein or the intermediate or finished products, by-products, waste or effluents thereof would (1) cause material impairment to the health of the persons engaged in or connected therewith, or (2) result in the pollution of the general environment.

The First Schedule of the Factories Act lists 29 hazardous industries.

6.7 Occupational (Notifiable) Diseases:

The Third Schedule under the Factories Act gives a list of 29 notifiable occupational diseases and poisoning.

Schedule III of the Workmen's Compensation Act 1923 also gives a list of 34 occupational diseases in its part A, B &: C. A similar list is also given by the ESI Act

Only statutory occupational diseases are listed above, but, there are many non-statutory diseases also which need accident or disease prevention. For details see Part 4 of Chapteir-24.. .

Thus legal terms accident, dangerous occurrence, dangerous operation, hazardous process and notifiable disease require *personal bodily injury, impairmental to health or environment pollution i.e. without these, they are incomplete.*

Thus those accidents (including diseases and poisoning) are given more attention, which pose **injury** to a person, property or environment.

7. THEORIES OF ACCIDENT CAUSATION

Various theories are developed to explain the phenomena of accident causation as under. They are useful to understand the mathods of prevention also.

7.1 Heinrich's Theory:

H.W. Heinrich, a pioneer in safety philosophy, first published his work. Industrial Accident Prevention, in 1931. Many of his principles and basic philosophy of accident causation and prevention are confirmed by time and application, but, some are also questioned and criticised. His philosophy is based on his 10 axioms (self evident-truths) as follows.

Ten Axioms of Industrial Safety:

1. The occurrence of an injury invariably results from a completed sequence of factors - the last one of these being the accident itself. The accident in turn is invariably caused or permitted directly by the unsafe act of a person and/or a mechanical or physical hazard.

2. The unsafe acts of persons are responsible for a majority of accidents.

3. The person who suffers a disabling injury caused by an unsafe act, in the average case has had over 300 narrow escapes from serious injury as a result of committing the very same unsafe act (see fig. 4.2). Likewise, persons are exposed to mechanical hazards hundreds of times before they suffer injury.

4. The severity of an injury is largely fortuitous the occurrence of the accident that results in injury is largely preventable.

5. The four basic motives or reasons for the occurrence of unsafe acts provide a guide to the selection of appropriate corrective measures. These are: Improper attitude. Lack of knowledge or skill, Physical unsuitability and Improper mechanical or physical environment.

6. Four basic methods are available for preventing accidents. These are Engineering revision, Persuasion and appeal. Personnel adjustment and Discipline.

7. Methods of most value in accident prevention are analogous with the methods required for the control of the 'quality, cost and quantity of production.

8. Management has the best opportunity and ability to initiate the work of prevention, therefore it should assume the responsibility.

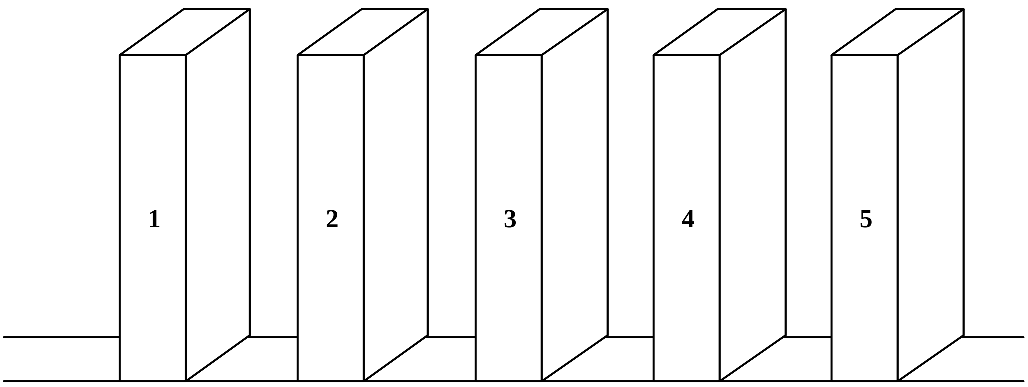
9. The supervisor or foreman is the key man in individual accident prevention. His application of the art of supervision for the control of work performance is the factor of greatest influence in successful accident prevention. It can be expressed and taught as a simple four step formula - Identify the problem, find and verify the reason for the existence of the problem, select the appropriate remedy and apply the remedy. The humanitarian incentive for preventing accidental injury is supplemented by two powerful economic factors: (1) The safe establishment is efficiently productive and the unsafe establishment is inefficient (2) The direct employer's cost of industrial injuries for compensation claims and for medical treatment is about one-fifth of the total (direct plus indirect) cost which the employer must pay.

These axioms were the first set of principles or guidelines ever set before in industrial safety and it has guided all safety activity till today. During the passage of 75 years, some of his axioms are questioned and disbelieved as truths, but, most of them are still true and deal with the important areas of safety, viz. accident causation and prevention, reasons of unsafe acts and conditions, management control functions, responsibility of organisation, costs of accident, safety and productivity etc.

Accident Sequence: *The five factors .in accident occurrence series in chronological order are:*

1. Ancestry and social environment.
2. Fault of person.
3. Unsafe act and/or mechanical or physical hazard.
4. Accident and
5. Injury

One factor is dependent on another and one follows because of another, thus constituting a sequence that may be compared with a row of dominoes placed on end and in such alignment in relation to one another that the fall of the first domino precipitates the fall of the entire row. An accident is merely one factor in the sequence. If this series is interrupted by the elimination or withdrawal of even one of the five factors that comprise it, the injury can possibly be prevented. See Fig. 4.3.



1. Ancestry & Social environment
2. Fault of a Person (undesirable traits)
3. Unsafe act or/and condition
4. Accident
5. Injury

Fig. 4.3 : Five Factors in Accident Sequence

In above dominos, social environment includes family and surrounding atmosphere in which a person is born and brought up. This is the origin or root cause of behavioural development as per H. W. Heinrich.

Undesirable traits include unsafe behaviour, negligence, lack of knowledge, violent temper, nervousness, recklessness etc.

Unsafe act or conditions are the results of undesirable traits.

Accident is caused because of unsafe act or condition 6r both.

Injury is the result of accident.

This suggests the steps of management controls as under:

Management Through Supervision

Controls

Human Failure
Knowledge – Attitude – Fitness – Ability

Which causes or permits

Unsafe Acts of Persons (88%)	Unsafe Mechanical, Chemical, Physical Conditions (10%)
1. Operating without authority or clearance, failure to secure or warn.	1. Unguarded, absence of required guards.
2. Operating or working at unsafe speed.	2. Inadequate support or guards, guards of improper height, strength, mesh etc.
3. Making Safety devices inoperative. 3	3. Defective, rough, sharp, slippery, decayed, cracked surfaces etc.
4. Using unsafe or defective equipment, or equipment unsafely or improperly.	4. Unsafe design of machines, tools, plant, equipment or supplies.
5. Unsafe loading, placing, mixing , combining, etc.	5. Unsafely arranged, poor housekeeping, congestion, blocked exists, etc.
6. Taking unsafe position or posture.	6. Inadequately lighted, sources of glare etc.
7. Working on moving or dangerous equipment.	7. Inadequately ventilated, impure air source etc.
8. Distracting, teasing, abusing, startling horseplay etc.	8. Unsafely clothed, no goggles, gloves or masks, wearing high heels etc.
9. Failure to use safe affair or personal protective equipment or devices.	9. Unsafe processes, mechanical, chemical, electrical, nuclear hazards etc.
10. Failure to warn co-workers or to secure equipment.	10. Inadequate warning systems.
11. Improper lifting.	11. Fire & Explosion hazards.

12. Servicing equipment in motion. 13. Use of drugs or alcohol.	12. High noise or vibration. 13. Hazardous dusts, gases, fumes vapours etc.

Which causes or permits

Accidents
98% Preventable type
2% Unpreventable
50% Practicably preventable

From other similar studies, Heinrich concludes that, "all agree in general that man failure is predominantly the proximate and direct cause of industrial, accident".

The Economic Times, Mumbai, of 21-9-97 gave following figures of Railway accidents:

Year	92-93	93-94	94-95	95-96	96-97
Failure of Railway Staff	363	358	351	237	249
Failure of other persons	60	72	76	71	59
Other causes	101	90	74	88	73
TOTAL	524	520	501	396	381

This supports Heinrich's conclusion that human failure is the predominant cause of accidents. However, this is not necessarily applicable to all or majority of the industrial accidents as per other theories.

To find out rate of human failure, software "Technique of Human Error Rate Prediction (THERP)" is available. See Part 1.15 of Chapter -19.

Criticism of Heinrich's Theory and His Reply:

H.W. Heinrich's ratio theory (fact finding from a study of 75000 accident cases) that 88% accidents are due to unsafe acts, 10% due to unsafe conditions and 2% unpreventable is criticised as follows:

Heinrich made his analysis from reports submitted to insurers by the managers of the companies at which the accidents happened. No manager would want to indicate to the insurer or to the safety authority or agency that the company had been at fault and that hazards existed in the workplace under his control. Such a statement may sound harsh but is borne by known practices, which also distort statistical data.

This ratio idea is fallacious because it rests on a false assumption that accidents are result of either unsafe acts or unsafe conditions. Actually there are multiple (combined) factors as supported by the results stated below.

A study conducted by the National Safety Council (USA) yielded the following conclusions:

18% injuries due to mechanical causes.
19% injuries due to personal causes.
63% due to a combination of both causes.

A study by the Department of Labour and Industry of the State of Pennsylvania yielded the following:

3% "due to mechanical causes.
2% due to unsafe acts.
95% due to a combination of both causes.

The ratio idea had done much harm and many employers still say, 'Why should first of all we spend a lot of money on only 10% mechanical causes? We will start after 88% personal causes are removed by the employees'.. Such concept is damaging. There are two essentials in every case of injury - there must be some degree, of hazard and there must also b~ faulty behaviour by someone. If the factor of hazard is properly detected and eliminated, there could be no injury. Similarly, if behaviour could be made and kept perfect, the result would be the same. Both these are the duties of every management It must try collectively to combat the combined causes of accident and should not separate the unsafe acts as employee's responsibility only. Law always stresses for employer's responsibility first. Why? Because the primary duty, money and ultimate control lie with the management to detect and remove unsafe conditions actions and to give necessary training to the workers. This is the only safe and healthy approach.

Heinrich is aware about the public debate and criticism of his 88-10-2% ratio in accident causation stated above and its wide spread that may influence people to ignore the machine guarding and to take the assumedly easier path of issuing instructions. In reply, he states his belief that the accident-prevention fraternity, like almost all professional groups, want all the pertinent facts and he has more faith in-their good judgement than to fear that they will ignore the very first common-sense step of safeguarding mechanical environment. *The machine is dangerous as man makes it so. It's man's use of the machine - more correctly, his abuse of it - that creates danger.*

He points out that judgement must be used in selecting the major cause when a mechanical hazard and an unsafe act both contribute to accident occurrence. Personal judgement may lead to error, but it is defensible and in the majority of cases results in fair conclusions.

The 300-29-1 Ratio (Foundation of lost-time accident - Explaining the foundation of a major injury, Heinrich estimates that in a unit group of 330 accidents of the same kind and involving the same person, 300 result in no injuries, 29 in minor injuries and I in a major lost-time injury. See Fig. 4.2. He explains this 300-29-1 ratio as an aid in accident prevention, because, it vividly emphasises preventive opportunity, when an employee, either because of his repeated unsafe action or repeated exposure to an unsafe mechanical condition, suffers 300 no-injury accidents (actual events such as slips and falls but fortunately not causing injury) surely there can be no lack of opportunity in preventive effort.

Replying misunderstanding and misquotation of this ratio, he states that this ratio is an average. Sometimes a major or serious injury occurs the very first time a person acts unsafely or is exposed to mechanical hazard – in other cases he is so endangered hundreds or thousands of times and may slip or fall many times before injury is sustained. In industry, where, employees are under supervision, these unsafe practices, conditions and the resulting narrow escapes from actual injury (events-accidents) are tangible and visible. They can and should be controlled long before one of the 300 no-injury accidents ultimately causes an injury.

In above ratio - cases, a major injury is any case that is reported to insurance office or to the State Compensation Commissioner. A minor injury is a scratch, bruise, or laceration such as is commonly termed a first-aid case. A no-injury accident is an unplanned event involving the movement of a person or an object, ray, or substance (slip, fall, flying object, inhalation etc.), having the probability of causing personal injury or property damage but not resulted in injury (near miss).

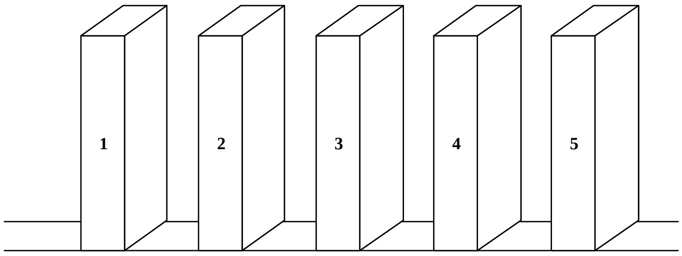
Safety and Productivity - Citing the study made by the Committee on Safety and Production of the American Engineering Council, Heinrich has narrated the detail findings some of which are given below :

1. Industrial accidents can be controlled under modern conditions of highly efficient productivity.
2. Efforts to improve safety performance do not interfere with production.
3. Maximum productivity is ordinarily secured only when the accident performance tends toward the irreducible minimum.
4. The cost of accidents is a loss in industrial operation, which should not be neglected.

7.2 Frank Bird's Domino Theory

Heinrich's theory of domino sequence is updated by Frank Bird Jr. to explain the circumstances that lead to losses (injury) in the chronological order of five dominoes.

These are shown in Fig. 4.4 and explained below :



1. Lack of control - Management.
2. Basic causes - Origins.
3. Immediate causes - Symptoms.
4. Accident - Contact, and
5. Injury/damage - Loss.

Fig. 4.4 : Frank Bird's Domino Sequence

Lack of control is the first domino and refers the fourth function of the management (planning, organising, directing, controlling and coordinating). It involves accident investigation, facility inspection, job analysis, personal communication, selection and training, 'standards' in each work activity identified, measuring performance by standards and correcting performance by improving the existing programmes. This first domino may fall due to inadequate standards, programmes and follow up.

Basic Causes (origins) are (1) Personal factors lack of knowledge or skill, improper motivation and physical or mental problems and (2) Job factors inadequate work standards, design, maintenance, purchasing standards, abnormal usage etc. These basic causes are origin of substandard acts and conditions and failure to identify them permits the second domino to fall, which initiates the possibility of further chain reaction.

Immediate causes are only symptoms of the underlying problem. They are substandard' practices or conditions (known I as unsafe acts and unsafe conditions) that could cause the fourth domino to fall. These causes should be identified, classified and removed by appropriate measures.

Accident or incident is the result of unsafe acts or/and unsafe conditions. This point is the contact stage. Some counter measures employed are deflection, dilution, reinforcement, surface modification, segregation, barricading, protection, absorption, shielding etc.

Injury includes traumatic injury, diseases and adverse mental neurological or systemic effects resulting from workplace exposures. 'Damage' includes all types of property damage including fire. The severity of losses involving physical harm and property damage can be minimised by prompt reparative action, salvage in the case of property damage and fire control devices and trained personnel.

Frank E Bird, in 1969, analysed 1753498 accidents reported by 297 companies of America. His conclusion is shown in Fie. 4.5.

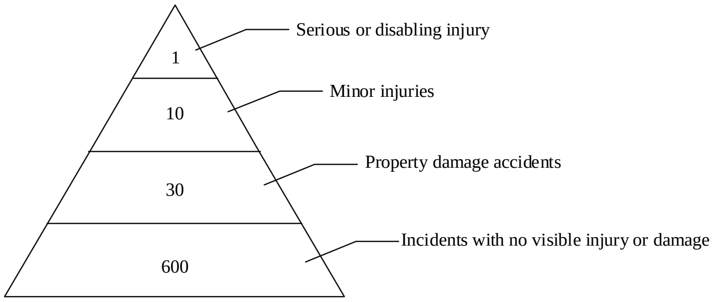


Fig. 4.5 : The Bird's accident ratio study

Inference of this 1-10-30-600 ratio is that 630 no injury accidents, with 10 minor and I major (serious) injury accidents, provide a much larger basis for many opportunities to prevent any injury accident. Out of total 641 events, only 10 may result in minor injuries and only 1 in major injury. But this can happen at any time not necessarily at the end.

7.3 Hepburn's Theory

H.A. Hepburn amplified the above Heinrich's theory and arrived at the principle that an injury accident is the result of the convergence at the same point of time of 4 factors (1) Unsafe actionable (2) Unsafe conditional (3) Proximate casual and (4) Personal.

Unsafe Actionable
↓
Personal → Accident ← Unsafe conditional
↑
Proximate casual

Here unsafe actionable and conditional factors are as usual Personal factor means person injured or likely to be injured by an accident and die person causing the accident. The proximate factor is that immediate causative factor such as failure of a brake, sudden exposure to gas etc., which by its reaction causes a sudden closing together or convenience of all the four factors to cause an injury accident He emphasises that lie four factors are complementary to one another m causation of any injury-accident such that, if any one or more can be withdrawn by any means during or just before convergence, an injury accident can be prevented. The event of an accident will not be prevented by efforts to control any one of the factors to the exclusion of the others. Remedial measures must be adopted for each of the factors. Like Heinrich he also suggested planning and organizing to prevent unsafe actions and remove unsafe mechanical or physical conditions.

7.1 V.L. Grose's Multiple Causation Theory:

As per this theory many contributing factors combine together UK random fashion, causing accidents. Such factors should be identified. As shown in figure 4.6, mostly man, machine and media interact with each other to generate causes for accident and management has to identify them and provide necessary safety measures.

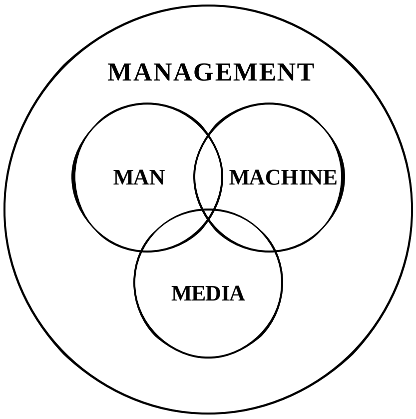


Fig. 4.6 : Multiple intersecting cause

In this theory

1. Man includes- workers, public etc.
2. Machine includes- equipment, vehicle etc.
3. Media includes- environment, weather, roadways etc.
4. Management means within which above three parameters operate i.e. to be controlled by the management.

Characteristics of –

1. Man includes- age, sex, height, skill level, training, motivation etc.
2. Machine includes- size, weight, speed, shape, material of constriction, energy etc.
3. Media includes- pressure, temperature, content, contaminants, obstruction on road etc.
4. Management includes- structure, style, policy, procedure, communication etc.

Simple example of this theory is a man slipping due to walking on a banana skin lying on .the road. Here main contributing factors are as under:

Man - A man walking on the road. Machine or object or vehicle - Slipprery banana skin.

Media - Hard road.

All above causes are interacting with each other to lead to the accident. Absence of any one cause can avoid the accident This indicates that slippery banana skin should be removed from the road or man should be more attentive for not walking on it or the road should not be so hard to cause slipping.

Let us take another example of a worker falling from a ladder. As per the domino theory an investigation is as under :

The unsafe Act	Climbing the defective ladder
The unsafe condition	The defective ladder
The remedial measure	Remove or repair the defective ladder and train that worker

As per the multiple causation theory some of the contributing factors surrounding this accident can be found out by asking :

1. Why was the defect in ladder not found in normal (past) inspections?
2. Why did the supervisor allow its use? Why did he not get it repaired urgently?
3. Didn't the injured worker know he shouldn't use it?
4. Was he properly trained or not?
5. Was he reminded or cautioned?
6. Did and do the supervisor examine the job first?

The answers to these and similar questions would suggest the following measures:

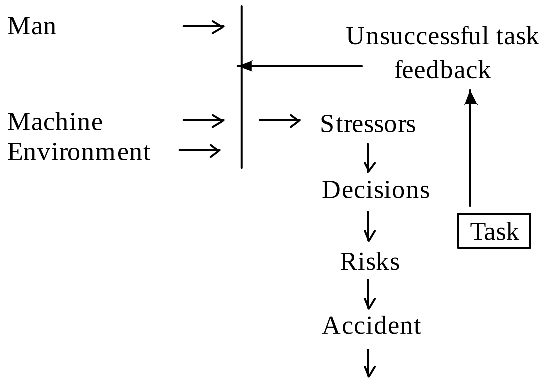
1. An improved inspection procedure.
2. Repairing the ladder (machine-tool, job etc.) immediately i.e. not waiting for an accident.
3. Improved training and supervision.
4. Better fixation of responsibilities.
5. Pre job planning and checking by supervisors.

Thus application of the multiple causation theory leads us to deep causation analysis and improved management systems are suggested to eradicate the problem from its origin. The range and depths of the multiple causation factors provide much details of long-run safety measures.

7.5 Systems Model Theory :

Similar toV.L. Grose's multiple causation theory, Bob Firenze developed a system model theory as under:

Here interaction between man, machine and environment (basic pre-elements for any accident) leads to an accident if the information available to the important element of the system is inadequate. If the risk is high and the decisions based on information are illogical and unsound, an accident occurs resulting into incompletion of the task. Bob Firenze's system model is shown below:

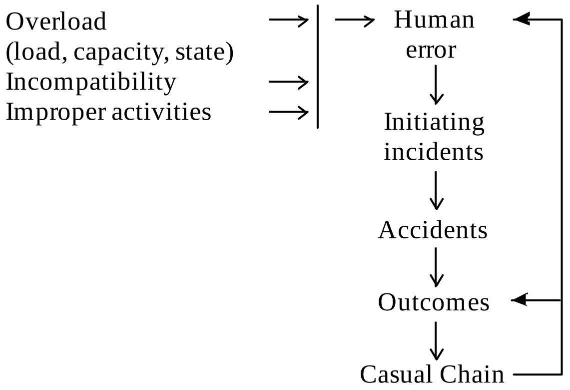


This necessitates the introduction of feedback system (as shown in diagram) to find out the faults/ causes in man, machinery and environment. The information that the man possesses can be strengthened through training. The stressors can be precedent in the following form -

1.	Psychological stressors	Anxiety, aggressiveness, fatigue.
2.	Environmental stressors.	Glare, temperature extremes and low levels of illumination, also includes 'Machine stressors' like unguarded machines at the point of operation, transmission of power and other dangerous parts.
3.	Physiological stressors	Narcotics & Alcohol.

7.6 Ferrell's Human Factors Theory:

Dr. Russell Ferrell, Professor of Human Factors al the University of Arizona, gave this theory of accident causation as shown in diagram below:



This theory states that accidents are the result of a casual chain (as in multiple causation theory), one or more of the causes being human error, which is in turn caused by three situations - overload, incompatibility and improper activities. Factors affecting these three situations are as follows :

1. **Overload** (A mismatch of capacity, load and a state) due to-

(a)	Load	Task (Physical, information processing)
		Environment (Light, noise, distraction, stressors, that requires active coping)
		Internal (worry, emotional stress)
		Situational (Ambiguity of goals or criteria, danger)
(b)	Capacity	Natural endowment, physical condition, safe of mind, training, drugs, pollutants, pressure, fatigue, stressors that impair ability to respond.
(c)	State	Motivational level and arousal level.

2. **Incompatibility** (incorrect response or mismatch) due to -

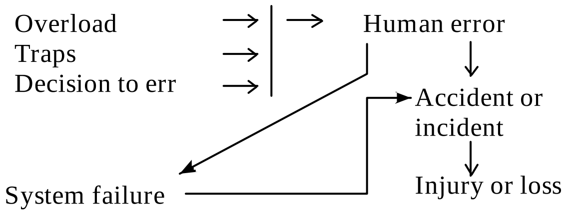
(a)	Stimulus – Response	Due to control – display
(b)	Stimulus – Stimulus	Due to inconsistent display types
(c)	Response – Response	Due to inconsistent control types or locations.
(d)	Work station	Size, force, reach, feel

3. **Improper** Activities due to
   (a) The worker did not know how to do it.
   (b) He deliberately took risk due to
   — low perceived probability of accident
   — low perceived cost of accident

Since this is basically human factor model, greater emphasis is placed on the first two causes of human error, overload and incompatibility.

7.7 Petersen's Accident – Incident Causation Theory :

This theory adapts Ferrell's human factors of overload and (also Heinrich's domino theory and states that causes of accident/incident are human error and/or system failure. Human error is due to overload, traps and decision to err. Human error may directly cause accident or may cause system fa ilure which may cause accident resulting in injury or loss as shown below:



Factors causing overload are much the same in Ferrell's model.

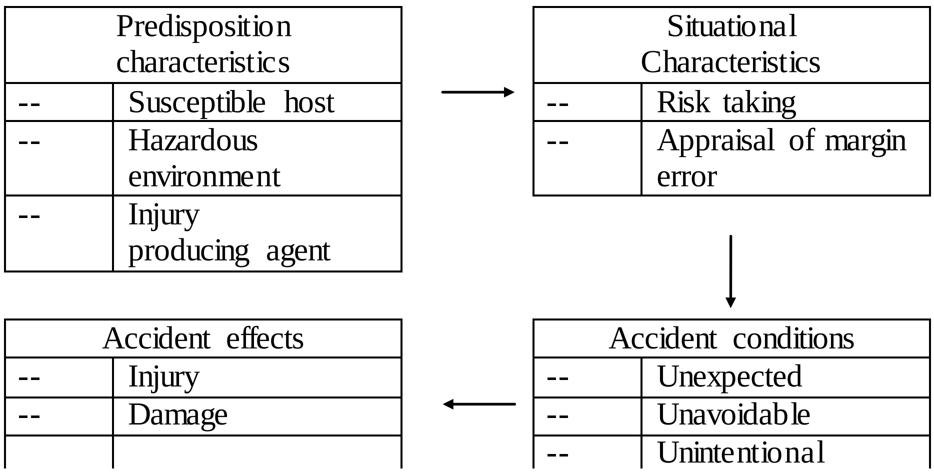
Traps are due to defective workstation, design and incompatible displays or control.

Decision to err are caused by illogical decision under situation, unconscious desire to err and perceived low probability.

System failure is due to error in policy, responsibility, authority, accountability, measurement, inspection, correction, investigation, orientation, training, selection, safe operating procedure, standards, hazard recognition, records, medical and others.

7.8 Epidemiological Theory:

Suchman stated epidemiological definition of accident as "An unexpected; unavoidable, unintentional act resulting from the interaction of host (accident victim), agent (injury deliverer) and environmental factors within situations which involve risk taking and perception of danger". His model is shown below:



This originated from the study of epidemics. Casual association between diseases or other biological processes (accidents) and specific environment are studied. A classic example of epidemiological method was given by Snow who discovered that persons using a particular water supply had a higher death rate from cholera than others. Gordon and McFarland supported that accidental injuries could be studied with the same techniques.

7.9 Surry's Decision Theory:

Jean Surry developed this theory stemming from .the epidemiological model of Suchman. It assumes that by a person's action or inaction, danger occurs to the person. If any negative responses to the question are shown during the danger build-up cycle, the danger becomes imminent. If all replies' are positive, the danger diminishes. A negative response to one of the questions will lead to inevitable injury. An accident can be the result of many different routes through the model (20 routes). There are fewer routes leading to no-injury situations.

7.10 Energy (Release) Theory :

Dr. Leslie Ball, former Director of Safety for NASA, introduced a causation theory. His thesis is that all accidents are caused by hazard, and all hazards involve energy, either due to involvement with destructive energy sources or due to a lack of critical energy needs. This model is most useful to identify hazards and to understand system safety.

Gibson noted that injury to a living organism can be only by some energy interchange. Hence it was suggested that the energy exchange should be considered as the injury agent. The energy exchange resulting in an injury could be mechanical, chemical, thermal, electrical etc. This concept is useful in understanding the way injury is caused and examining the solutions. When a grinding wheel is in stop-position it does not make accident, but if it runs and fingers trapped, it makes accident because of its kinetic energy.

William Hadden, m 1970, explained 'energy transfer or release' as the main factor for accident causation and said that accidents and injuries are caused because of transfer or release of energy between objects, events or environment interacting with people.

Ten strategies were suggested by Hadden to prevent or reduce losses as under:

1. Prevent the transfer or origin of energy, e.g. safe substitution - using toluene instead of benzene, not keeping the car running, dipping instead of spraying, shot blasting instead of sand blasting.

2. Reduce the amount of energy trailer, i.e. drive vehicle or machine at slow speed, reduce quantity or concentration 'of hazardous chemicals.

3. Prevent release of energy, e.g. flameproof electric fitting in flammable area, fall arrester device, dyke to stop spread of .chemical, safe overflow pipe or level cut off device.

4. Change the rate of release or distribution of released energy, e.g. reduce the road slope, use inhibitor to reduce rate of reaction, sprinkler to reduce rate of burning, scrubber to scrub toxic gas, condenser to liquefy organic vapour.

5. Divert (separate) the energy released in time or space, e.g. separate paths for vehicles and pedestrian traffic, keep electric wiring or pesticide out of reach, discharge gases at height

6. Provide barrier between the energy released and a structure or a person likely to be affected, eg. guards on machines, radiation shield, filter, safety goggles, earplugs, insulation on hot surface, blast wall against explosion energy.

7. Make the surfaces of structure safe. e.g. rounded corners, blunt objects, big handles of tools and no sharp edges.

8. Strengthen the structure or person susceptible to damage, e.g. fire resistant wall, training to workers and vaccination for disease.

9. Early detection ,of damage and actuate counter effect, e.g. fire detectors with sprinklers, high level alarm and tripping of feed pump, temperature alarm and starting of cooling system.

10. Speedy measures to restore normal condition, e.g. rehabilitation of injured worker, repairing of a damaged machine or vehicle.

See Part 5 and 6 of Chapter-2 for safety philosophy on accident causation.

8. PRINCIPLES OF ACCIDENT PREVENTION

After understanding the causation of accidents, it is obviously essential to understand the principles and techniques of accident prevention. But before that we will see the types of accidents first.

8.1 Types of Accidents:

Based on severity of injury, accidents are major, minor or near miss type. The combination of injury and property damage gives four types of accident as follows:

1. Injury and property damage (major).
2. Injury and not property damage (major or minor).
3. Properly damage and not injury (major or minor).
4. No property damage and no injury (near miss). Based on causation, they are of five types:
1. **Psychological causes** - such as inexperienced, not motivated for safely, worry, emotional, wrong attitudes etc.
2. **Physiological causes** - such as age, sex, body-build, poor hearing, vision, strength etc.
3. **Physical causes** - such as heavy workloa4, long working hours, no rest, unhealthy work environment, work at height, depth, or in confined space, falling toad etc.
4. **Mechanical, Electrical, Chemical, Radiation causes** - such as unguarded machinery, defective equipment, noise, vibration, obstructed pathway, sharp edge, electric shock, static electricity, chemical, poison, toxic gas, acid, fire, explosion, radiation etc.
5. **Environmental causes** – Weather effects, heat, cold, humidity, air, wind, ram, tyde, lightening etc.

Causes of type No.1 and 2 give rise to unsafe action while No. 3 to 5 give rise to unsafe conditions.

8.2 Fundamentals of Accident Prevention:

As explained by Heinrich, accident prevention is both, science and art. It represents control of performance of man, machine and physical environment.

The word 'control' includes prevention as well as correction of unsafe conditions and actions. Prevention is the first or initial part of 'control' which if practised, subsequent control for consequence or effect may not be needed. Thus accident control is a vital factor in every industry, which if ignored or practised unskillfully, leads to needless human suffering and business bankruptcy.

The accident-prevention task requires both, the short term approach (direct control of personal performance and environment) and the long-tern approach of instruction, training and education. This task must be performed before an accident and injury occur. Subsequent efforts after accidents are also necessary.

Thus accident prevention may be defined as an integrated programme, a series of co-ordinated activities, directed to the control of unsafe acts and unsafe conditions and based on knowledge, attitude and ability for safety. It aims to serve industry, country and humanity.

Five basic or fundamental steps for accident prevention (safe and efficient production), suggested by H.W. Heinrich, are:

1. Organisation.
2. Fact finding.
3. Analysis of the facts found
4. Selection of remedy and
5. Application of the remedy.

Sixth step of 'Monitoring' (i.e. measurement o: result, assessment i.e. comparison with legal criteria or standard, feedback and further improvement) is also suggested. Such review is necessary after all safety progrmmes.

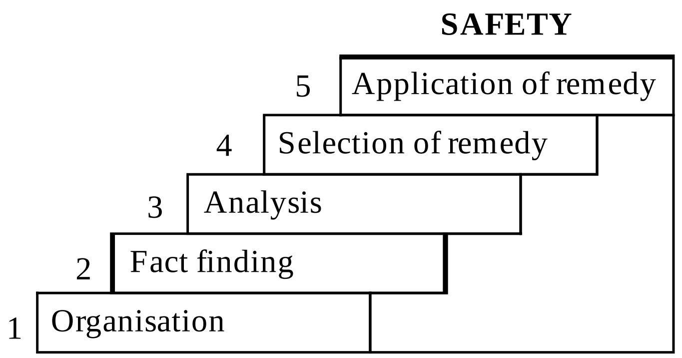


Fig. 4.7 Steps of Accident Prevention

8.2.1 Organisation:

As shown in Fig. 4.7, organisation is the first step of accident prevention ladder.

The safety organisation, management or at least the planned procedure, which it represents, is the vehicle, the mechanism by means of which interest is kept alive and the safety programme is designed, directed and controlled. The actual work of prevention is done by safety director or manager, safety officer and the line and staff supervisors with the active support of top management. See Chapter-6 on safety management.

Safety is not only a staff function but it is a line function also. Budgetary provision (cost allocation) for safety should be made from very beginning.

Here organisation does not mean safety department only. Safety is not a function of one department only. All the members of organisation (including all departments) have to contribute and play their role for safety.

Basic philosophy and safety policy for accident prevention and firm determination of the top management are utmost necessary.

Organisation also includes single person working for safely.

8.2.2 Fact Finding:

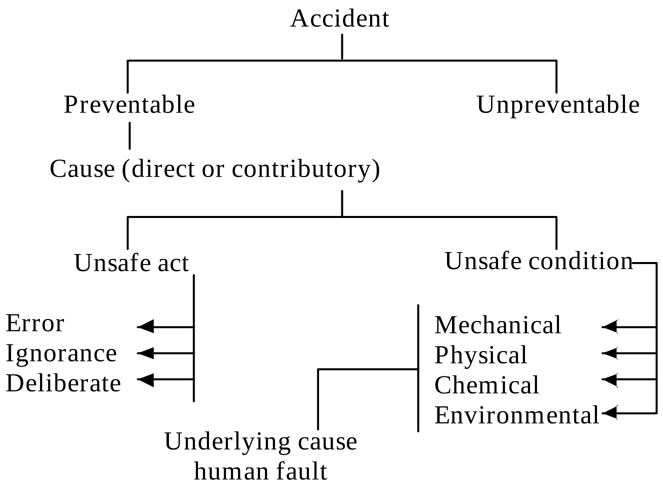
The knowledge of probable or potential hazards (facts) is derived from surveys, inspections, safety audits, observations, review or records, inquiry, investigation and judgement.

Facts include past, present and future facts which have caused and which can cause accidents Past causes can be known by 'accident records' and inquiry. Future (hidden) causes can be known by HAZOP, HAZAN, safety audit, inspection etc.

The term "hazard" is synonymous with the phrase "direct and proximate accident cause" i.e. the unsafe personal act and/or unsafe physical mechanical, electrical, chemical, environmental condition without which no accident can occur.

Personal hazards (unsafe acts) are violations of commonly accepted safety rules, practices and procedures. Mechanical hazards (unsafe conditions) are of four groups: Static, kinetic, electrical and chemical (including radioactive or nuclear).

Heinrich classifies main causes of accident as under:



The proximate cause is the nearest in 'efficiency' rather than whether it was closest in time or not.

13 unsafe acts and 13 unsafe conditions are listed in foregoing Part 7.1 entitled 'Heinrich's theory of accident causation'. These are some general heads or categories under which more specific acts may be grouped. For example, the general head "Making safety devices inoperative' can be sub-itemised as:

1. Removing guards.
2. Tampering with adjustment of guard including making interlock guard inoperative.
3. Beating or cheating the guard.
4. Failing to report defects etc.

Two types of main facts - unsafe acts and unsafe conditions – are discussed below.

(1) Unsafe Acts:

Unsafe act is a human action resulting in accident or injury to him, others, environment or all. See also Part 3.94 of Chapter - 2 for definition of 'unsafe act'.

Some reasons of unsafe acts are as under:

1. **Improper Attitude -** Wilful disregard, reckless, lazy, disloyal, non co-operative, fearful, oversensitive, egoist, jealous, impatient, absentminded, excitable, obsession, phobia, inconsiderate, intolerant, mentally unsuited and other psychological reasons.

2. **Lack of knowledge or skill -** Insufficiently informed or trained misunderstands, not convinced of need, indecision, inexperienced etc.

3. **Physically Unsuited -** Due to hearing, sight, age, sex, height, ill, allergic, slow reaction, crippled, intoxication, physically handicapped and other physiological reasons.

4. **Physical conditions -** Space, light, ventilation, heat, layout or arrangement, materials, tools, equipment, procedures, company policy, routing etc. make it awkward, difficult, inconvenient, embarrassing or impossible to follow safe practice rules.

Unsafe act should be noticed as early as possible and removed just after it is noticed. Purpose should be of removing injury, to prevent recurrence and not to punish any individual.

Workers should be properly observed for their unsafe act by seeing their selection and use of –

1. Position of their standing and working.
2. Tools and equipment including hand tools, power tools, lifting tools, PPE, FFE etc.
3. Method or procedure adopted by them.
4. Traffic arid driving rules.

Position and working should not be in dangerous conditions. Tools and equipment should be of correct size and type, should be used correctly and in right condition. Procedure or method should be safe and adequate. Where safety work permit is required, it must be explained and followed correctly. Driving should be safe or defensive and traffic rules must be followed. Drivers of vehicles of hazardous goods should have undergone specific training.

After seeing an unsafe act, observer's (e.g. supervisor or safety officer) attitude should be to 'talk with' the worker and not to 'talk to' the worker. This means to call or advise the worker politely, ask him why he is doing so or not using required tool, equipment, procedure etc., hear his explanation, try to understand him and then explain him the 'underlying hazard' and make him convinced about 'unsafe act' and to correct it as per safety requirement.

Some examples of unsafe acts and control measures are given in **Table 4.1:**

Table 4.1: Unsafe Acts, Remedies and Responsibilities

	Unsafe Actions or Behaviouristic Causes		Remedies		Responsibilities
1	Age, sex, experience		Proper selection of personnel		Personnel Dept.
2	Physical and physiological conditions such as work-load, physical strain, physical weakness, headache, cold, faintness, abnormal blood pressure, poor vision, handicapped, deaf, dumb, epilepsy etc.	A	Workload study and proper distribution	A	Supervisor, Safety Officer
		B	Pre-employment medical exam.	B	Physician, Factory Medical Officer
		C	Periodic medical exam.	C	Physician, Factory Medical Officer
		D	Proper selection & placement of person	D	Personnel Dept. and Psychologist.

3	Poor attitude and inability such as inattentive, insubordinate, un-cooperative, critical of supervision, bad skill or motives, wrong habits, intoxication, chance taking, absent minded, disregard of safety rules & instruction etc.	A	Pre-employment psychological or ability tests	A	Personnel Dept. and Psychologist.
		B	Supervision	B	Supervisor
		C	Discipline	C	Supervisor and Personnel Dept.
		D	Personnel work	D	Personnel Dept.
4	Human errors such as intentionally performed, due to – behaviour Components, personal factors, situational factors,, and lack of knowledge, training etc.	A	Mechanical, electrical, physical, chemical safeguards and safety rules	A	Safety & other Engineers
		B	Safety education, training, meeting, contest, posters, maintaining interest and awareness.	B	Supervisor and Safety Training Dept.
		C	Job analysis and revision	C	Production and Safety Manager.
5	Emotional factors such as worry, hurry, fatigue, accident proneness or tendencies, home or social difficulties, loss of sleep, periodical emotional disturbances etc.	A	Pre-employment tests	A	Personnel Dept. and Psychologist.
		B	Supervision	B	Supervisor
		C	Maintaining interest and awareness	C	Supervisor and Safety Officer
		D	Critical incident technique	D	Expert

(2) Unsafe Conditions :

See Part 3.95 of Chapter - 2 for definition of 'unsafe condition'.

Unsafe condition is created by an unsafe act of a person or act of God or by any agency or due to failure or weakening of any material, structure, situation, condition or system.

Observance of unsafe conditions includes many areas such as proper lighting, ventilation, housekeeping, floors, platforms, handrails, toe guards, machine guards, tanks, vessels and pipelines, safety fittings and devices, electrical hazards, fire prone condition, gaseous and dust exposures, noise, vibration, heat or atomic radiation, loading, unloading and transportation etc.

Such unsafe conditions are due to non-provision, non-maintenance, poor-maintenance, poor-supervision, lack of training, improper design and layout of plant & machinery, poor lighting, poor ventilation, absence of guards and safety devices, failure of safety devices, equipment or tools, unsafe structure, poor housekeeping, fire-prone area, sources of ignition, static electricity, slippery floor, high noise, vibration, radiation etc.

Observation for unsafe working conditions should include basic techniques of look, listen, smell and feel (LLSF) to detect unusual condition of situation, position, noise vibration, odour, temperature, pressure, out of control etc.

Some examples of unsafe conditions and control measures are given in Table 4.2:

Table 4.2 : Unsafe Conditions, Remedies and Responsibilities

	Unsafe Actions or Environmental Causes		Remedies		Responsibilities
1	Atmospheric conditions such as contents of air, temperature, humidity, ventilation, rain, lightening etc.	A	Air sampling, monitoring, cleaning and conditioning.	A	Engineering and utility Dept.
		B	Humidity Control.	B	Humidity or Engg. Dept.
		C	Improve natural and artificial ventilation by efficient exhaust systems.	C	Engineering Dept.
2	Illumination, its distribution and diffusion – direct glare, reflected glare, shadow and colour	A	Improve natural and artificial illumination.	A	Lighting or Engg. Dept.
		B	Good design and plant layout.	B	Plant Engineer
		C	Proper colour	C	Colour expert
3	Workspace, overcrow ding, obstruction etc.	A	Proper spacing, area, height machinery layout, headroom.	A	Plant Engineer, Civil Engineer.
		B	Good design and housekeeping.	B	Plant Engineer, Supervisor
4	Bad housekeeping, rubbish, disorder, unplanned layout	A	Good housekeeping, orderliness, cleanliness, planned layout.	A	Plant Engineer, Safety Officer
5	Inherent properties and design defects of materials, machines, equipment, buildings etc.	A	Good design, good materials, good construction & maintenance good procedures conforming to standards.	A	Design Engineer, Plant Engineer, Safety Officer, Purchase Dept.
6	Improper guarding like no-guard, inadequate guard, no maintenance etc.	A	Regular inspection.	A	Supervisor, Safety Officer
		B	Include guards in original design order & contract.	B	Chief Engineer, Purchase Engineer, Safety Officer
		C	Provide and maintain guards for existing hazards.	C	Supervisors.
7	Defective materials, tools, equipment, vessels, stairs, pits, tanks, objects etc.	A	Regular inspection.	A	Supervisors
		B	Preventive and corrective maintenance.	B	Maintenance Dept.
		C	Good source of supply.	C	Purchase Dept.
8	Unsafe methods, procedures etc. resulting in unsafe condition.	A	Job safety analysis	A	Production or Plant Manager, Safety Officer
		B	Job training	B	Training Officer, Supervisors
		C	Safety rules & procedures.	C	Dept. Head & Safety Officer
		D	Inspection and Correction.	D	Supervisor, Safety Officer
9	Rate of Production	A	Proper speed of work.	A	Production Manager
		B	Time study, Motion study, job study, machine study etc.	B	Supervisor, Safety Officer
10	Noise & Vibration	A	Noise measurement & controls.	A	Plant Engineer
		B	Use of ear plugs, ear muffs etc.	B	Supervisors, Safety Officer
		C	Vibration detection & controls.	C	Plant Engineer, Supervisors
11	Long working hours or excessive workload	A	Supervision	A	Supervisors
		B	Regulation of Law.	B	Personnel Dept.
12	Insufficient or improper	A	Provide sufficient & good	A	Personnel Dept., Chief

	welfare facilities, clothing, PPE etc.		facilities of toilet, urinals, washroom, lunch room, canteen etc.		Engineer
		B	Provide safe clothing & PPE.	B	Personnel Dept. Supervisors.
13	Hazards in chemical industries, processes, storage, transportation etc.	A	Detection of hazards by various techniques.	A	Supervisors, Safety Dept. Technical Dept.
		B	Application of appropriate remedy such as safe guards & fittings, safety devices, elimination of hazard, minimization of hazard level, lockouts, trips, alarms & interlocks, isolation, fail-safe design, failure minimization, failure rate reduction, screening, scrubbing, monitoring i.e. sensing, measuring, responding, and warning (audiovisual) of dangerous parameters, remote controls, microprocessors, recorders, auto controllers etc.	B	Chief Engineer, Plant Engineer, Production Engineer, Chemical Engineer, Supervisors, Safety Officers.
14	Emergencies & Disaster	A	Onsite Emergency Plan	A	Chief Executive, Safety Officer, Fire Officer, Emergency Staff
		B	Offsite Emergency Plan	B	Govt. authorities, mutual aid members, associations etc.
15	Act of God and unexpected events	A	Assessment and safe planning.	A	Design Engineer., Top Management
		B	Onsite Emergency Plan.	B	Chief Executive, Safety Officer, Fire Officer, Emergency Staff

Facts from Accident Reports:

Form No. 21, 21A and 29, under the Gujarat Factories Rules and Annex -13 under the Electricity Rules prescribe some facts for accident reporting which should be referred for information.

Facts should include 'past facts' of accidents already happened and 'future facts' of possible accidents based on various hazard identification techniques such as Hazop, Hazan, risk assessment, FTA, ETA, etc as stated in Part 4 of Chapter - 19.

8.2.3 Analysis of the Facts :

The third step to accident prevention is analysis of the facts found. This is defined as the work of drawing conclusions from assembled data. The hazards are here named, identified and classified or analysed. Such work is done by (a) Analysis of past experience (b) Survey and inspection (c) Judgement and experience plus enquiry. Identify the direct causes, sub-causes, underlying major causes, types of accident, operations, tools and equipment obstacles, frequency, severity, location, occupation etc., and classify them.

The supervisor's report of accident investigation is the basis of all analysis of past and present accidents. It is the most important, difficult and skilful task requiring good knowledge and experience. Decide very carefully that which is the unsafe act, which is the unsafe condition, which is more proximate and the accident is due to any one or their combination and in which sequence. From facts, witnesses and rational judgement find reply to all these questions and report properly for real accident reporting and true causation study.

Twelve steps (safety officer's procedure) to analyse the causes of accidents are as follows :

1. Obtain the supervisor's report of the accident containing the details given above.
2. Obtain statutory accident report form.
3. Obtain the injured person's report.
4. Obtain the reports of witnesses if any.
5. Obtain the doctor's report on injury. .
6. Investigate the accident.
7. Record all evidences and facts.
8. Tabulate the essential facts of the accident together with the similar past accidents.
9. Study all the facts.
10. Analyse accident causes in details. Such analysis will classify causes as defective or no guard, poor lighting, poor ventilation, no safety devices, no use of PPE, accidents - fatal or nonfatal, male or female wise, day or night wise, age wise etc.
11. Arrange the causes in order of importance or priority of compliance.
12. Find and record reasons of existence of those causes.

After finding potential hazards, cross analysis of records must be made to select most important hazards or targets. Reasons for existence of hazards must be found for correction.

Appraisal, analysis, inspection and control techniques are separately discussed in details in Chapter-19.

8.2.4 Selection of Remedy:

When it is analysed to indicate, which is the proximate or main cause that needs to be corrected then it suggests the fourth step of selection of remedy for the named (analysed) hazards. Four basic remedies 'are as under:

Four Basic Remedies:

1. **Engineering Controls :** Guarding of machine and tools, isolation of hazards, revision of procedures and processes, good illumination, ventilation, colour and colour contrast, substitution of safer materials and tools, replacement, reduction, repair and a variety of mechanical, physical and chemical remedial measures for which the most of the chapters of this book are developed.

2. **Instruction, Training, Persuasion and Appeal:** Regular training as well as instruction, reinstruction, persuasion, appeal, notice, posters, supervision and motivation.

3. **Personnel adjustment:** Selection and placement with regard to the requirement of the job and the physical and mental suitability of the worker, medical examination, treatment, advice and PPE. 4. Discipline: Mild admonition, expression of disappointment, fair insistence, statement of past record, transfer to other work and penalties.

In the process of selecting an effective remedy, 'Engineering Control' takes the first place and discipline as the last resort. Select the most effective and urgent remedy first and then precede priority wise.

8.2.5 Application of the Remedy:

The final step in accident prevention is application of the selected remedy.

If machines, tools, vessels, equipment, structures, procedures etc., are unsafe, they must be guarded, ' replaced, revised or otherwise made mechanically safe or accident free. This is management's responsibility. The safety officer/engineer will guide and the supervisors see to it that the necessary work is done.

If the personal performance is unsafe, employees must be selected, instructed, trained, cautioned, persuaded, convinced and appealed for improvement. Certain cases require proper placement, other medical or psychological treatment or advice. In rare cases and as a last resort, some form of disciplinary action may be needed.

Application of selected safety measures should be immediate and long-term. Existing unsafe conditions and actions should be corrected at once while at the same time long-term programmes should be started to include procedures and techniques devised to anticipate and prevent situations of a similar nature.

Application of remedy is the dynamic part of accident prevention. Unless the remedy is successfully applied, all prior steps are of no use and wasted.

(1) **Ways & Means of Application of Remedy:** A safety engineer or officer applies the following ways :

1. Prepares, presents and applies recommendations, suggestions summaries and plans.
2. Establishes a safety organisation.
3. Gets support of management and supervisory staff in applying the remedies.
4. Creates enthusiasm and co-operation up and down the line.
5. Satisfies himself by seeing the successful working of the remedies applied.

He will apply in chronological order the four basic remedies mentioned in the foregoing Part 8.2.4. Engineering controls call for designing, buying and building, installing and maintaining guards, safety devices and safety equipment. The persuasion and appeal remedy requires teaching, training, appeal, instruction, persuasion etc.

He must have ability to overcome obstacles in applying remedies. He should identify the obstacles as a person, attitude, condition or circumstance.

Constant follow-up action through safety administration is necessary. Detection and placement of physically impaired workers should be carried out carefully and effectively. In a typical one-man plant the employer himself has to carry out all such functions single-handedly. All employees are expected to work safely. Responsibility should be fixed and distributed for quick compliance. A supervisor or foreman is the key-man for such purpose.

Machine - accidents are controlled by effective engineering-revision. But many accidents take place in material handling for which two highly successful methods may be employed, (i) One lies in the study and improvement of methods and procedures to the end that some safer and better way or equipment may be found to conduct any particular operation than that in use. (ii) Secondly, it is most useful to utilise the proper degree of supervision - from the chief executives down to the foreman - that will result in the observance and correction of unsafe material handling practices on the part of the workers before injuries occur.

(2) Creating and Maintaining Interest:

The second basic remedy of persuasion, appeal, instruction and training requires vast efforts. The practice of creating and maintaining interest for accident prevention applies to employers as well as employees.

Group interest of employees is created and maintained by the safety organisation which includes moral and educational effect of accident investigation, publicity, posting and distribution of educational literature, safety films and slides, contests, prizes, awards, meetings and inspirational talks. See part 8.4 and 8.5 of Chapter -3 and Part 8.2.4 of Chapter -6.

Individual interest of employees is created and maintained by an appeal to personal characteristics listed below:

1. **Self-preservation** (Fear of personal injury) Featuring the injury by figures, posters, notices, meetings, oral discussion, lectures, films and slides are useful to maintain the strongest and commonest human instinct of self-preservation or self-protection.

2. **Personal and material gain** (Desire for reward) Bonus, salary increase, vacation with pay, days off, trips, personal gifts, requisite assignments of work,, banquets, picnics and participation in safety activities prove useful in this regard.

3. **Loyalty** (Desire to co-operate) Effect of accident by the employees on supervisor's record, on employer's overhead cost, on quality of product, on fellow employees and on company's prestige must be brought to the notice of individual to create and maintain their sense of loyalty to the employer.

4. **Responsibility** (Recognition of obligation) The sense of responsibility, both to self and to others, is created by assignments and analogy of observance of safety rules.

5. **Pride** (Self satisfaction and desire for price) Pride increases ability to work. Praise exhibits, awards and insignia, differentiation of workers having outstanding safety record by giving them special hat/dress, reward etc., are useful in this regard.

6. **Conformity** (Comparison with standards or good examples) Some methods of appeal are: Standards (Safe practice rules, codes, procedures etc.), comparison, system and regularity, leadership of good example in safe conduct, ridicule, etc.

7. **Rivalry** (Desire to compete) Man is a highly competitive animal and creates better results when competing with other than when working alone. For this, provide opportunity, set up objectives and determine method of measurement

8. **Leadership** (Desire to be outstanding) The desire for leadership is strong in many persons which may be used to advantage in safety work. Such persons should be given additional responsibility in safety work and promotion etc.

9. **Logic** (Special ability to reason) Some persons have special ability to see both sides -of a question and to arrive at conclusions that are logical and just. Such persons should be used in safety work. A few methods of appeal to logic are basic philosophy of accident causation and prevention,

providing data relating to accident frequency, seventy, types and causes of accidents and remedial measures.

10. **Humanity** (Desire to serve others) Humanitarianism is a widely spread human instinct and strong appeal to everybody for safe performance. Safety is termed as Human Engineering on this ground where human is expected to be at centre. We have to fit the unfit to survive.

(3) Education:

All accident-prevention work is basically educational. Well-trained and careful men may avoid injury on dangerous work and untrained and careless men may be injured underlie safest possible conditions.

Safety education is meant to include meetings and talks, personal contacts with authorities or teachers, use of bulletins, posters, lectures and reading material, slides and films, computers, first-aid instruction and any oral or written instruction for avoiding hazards and cultivating safe methods of doing work.

Some of the most commonly used educational procedures are listed below:

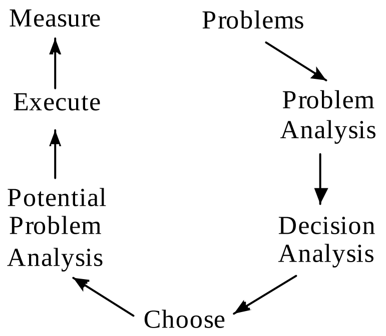
1. Regular safety coaching class for workers. Hazards, safety precautions, safety measures, safety duties and procedures should be explained in their own language.
2. Periodical safety class for supervisors, managers and top executives for co-ordinated efforts from all.
3. Safety meeting, conference, seminar, exhibition etc.
4. Publicity-Safety posters, slogans, maxims, notices, bulletins, pay-pocket-inserts, stickers, slides, films, house magazine etc.
5. Safety books, pamphlets, periodicals etc.
6. Safety contests, essays etc.
7. Safety plays and similar programmes.
8. Preparation of safety codes, standards etc.
9. Use of loyal employees in setting a good example.
10. Safety message on work orders, computers, correspondence etc.
11. Featuring specific safe-practice rules.
12. Investigation of accidents and explaining their analysis of unsafe actions, unsafe conditions and their remedial measures.
13. Conducting training programmes.
14. Sending persons to outside safety courses.
15. Specific programmes as per our own need and nature of work.

16. Conducting short-term safety course for all employees in rotation.

8.3 Models for Accident Prevention:

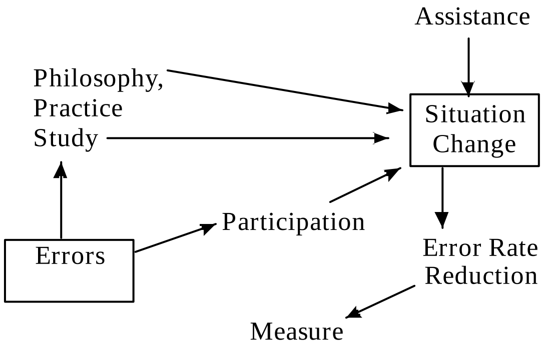
H.W. Heinrich's model of 'Five steps of accident prevention' is explained in previous Part 8.2 and shown in Fig. 4.7. The other relevant 'models given in Heinrich's book (ref. no. 1) are explained below in brief.

8.3.1 Kepner-Tregoe Model:



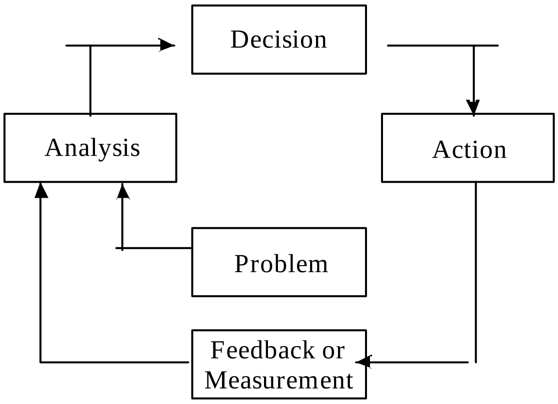
This model is very close to Heinrich's five step model shown in Fig. 4.7. 'Execute' means application of remedy. 'Measure' is a new step in this model, requiring measurement and monitoring of the execution.

8.3.2 Improving Human Performance (Error Reduction) Model :



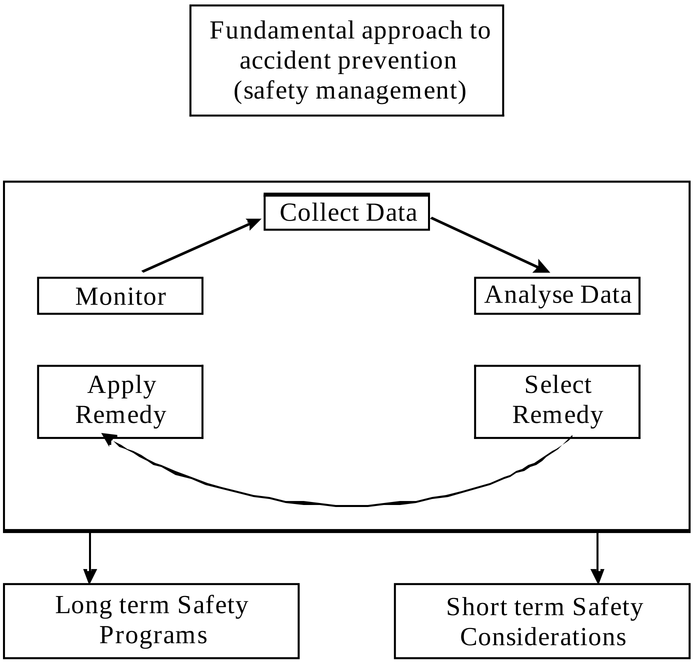
This model is discussed by Johnson in MOR1 (management oversight risk tree). Here errors are considered inevitable, situations error-provocative, rate of error measurable and reducible. Situation can be changed by study, practice and participation.

8.3.3 Performance Cycle Model :



Johnson has discussed this model in his MORT. Here five steps in sequence are problem, its analysis, decision, action and measurement of result. If may be again analysed for re-decision.

8.3.4 Updated Safety Management Model:



This is updated model of Heinrich's five steps model shown in Fig. 4.7. Here only one step of 'monitor' is added for monitoring of applied remedy and to reconsider the problem.

Basic philosophy of accident prevention is required at the root of any safety management. Monitoring is a feedback mechanism, it tells us how we are doing, what progress we are making. It dictates additional needs, we then collect additional data, analyse it, select additional remedies, apply them, monitor and so on.

8.4 Five 'E's of Accident Prevention

Safety or accident prevention can be achieved by the following five methods:

1. **Education & Training**
   (To prevent unsafe acts)

This has long-term and permanent effect. This is the most powerful remedy for unsafe act of the workers. It helps in finding out unsafe conditions also. The workers' safety training programmes should include (a) Understanding of specific hazards of then plant, process, building etc. (b) Safety rules and safe procedures (c) Training for specialised or difficult job (d) Job safety analysis and (c) Safety instructions for variety of jobs.

2. Engineering controls
(to prevent unsafe conditions)

Poor illumination and ventilation, unguarded machinery, mechanical, electrical, physical and chemical hazards, dangerous location or situation etc., are unsafe conditions which can be eliminated in the design stage or subsequent engineering revision and controls. This is the first and most effective remedy.

Some engineering controls are- substitution of less hazardous material, machine, method, process, vessel etc., risk reduction, process modification, isolation, segregation, guarding, fencing, barricading, enclosure, dilution, safe design; failsafe device and safety devices including alarms, trips, safety valve, NRV, PRV, EFV, FFE, etc.

3. Enforcement (of safety rules)

All statutory safety provisions should be followed for our own safety and safely of others. Self initiation for full compliance is necessary, otherwise government authorities may take action. In addition, other safety rules for our plant should also be framed and followed. Wilful neglect or disobey of safety rules or orders should be dealt with strictly.

Enforcement measures include - new law, amendment in old law, company safety rules, implementation and legal action.

4. Enthusiasm (to maintain interest)

Like a catalyst it adds to safety awareness and motivation. It should come from the top management to the lowest worker. It will keep the workers safety conscious. It can be developed and maintained by proper safety attitude, competition, prizes, awards, publicity, incentives etc.

This includes motivation and participation in safety programmes.

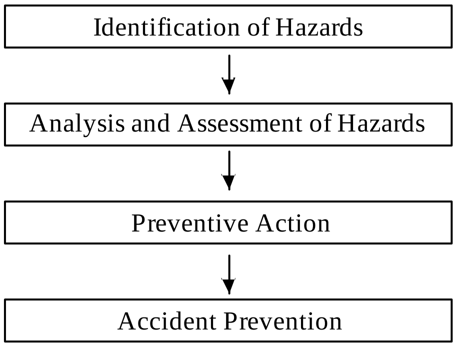
5. Example setting (to lead for safety)

The top executives, managers and supervisors should set an example to others by the self-enforcement of safety rules. Then others will follow them. This is a chain reaction to increase and maintain safety.

8.5. Approaches to Preventive Action:

Mainly there are two types of approaches.

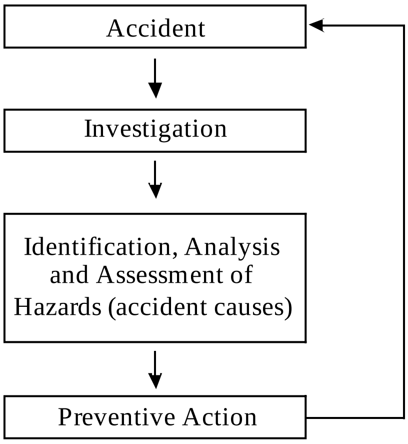
(1) **Proactive or Preventive Approach**
(Effort before accident)



In proactive or preventive approach, action is to be started without waiting for accident. Potential hazards are first identified, analysed and preventive programme is formulated to' remove or reduce the hazards identified. This approach is better then the reactive approach, but it incurs regular costs.

(2) Reactive or Corrective Approach

(Effort after accident)



Normal habit of a person or management is to follow this reactive or corrective approach only after an accident. They do not think to invest money or time for preventive measures to avoid accidents by advance planning. Drawback of this approach is to suffer some loss due to one or more accidents. In this approach, action is started after accident. Accident causes are investigated analysed and preventive action is determined. Then it is applied to prevent recurrence of the similar accident. This works as a lesson from the accident.

E X E R C I S E

1. Comment on the following Statements by giving your opinion:

1. Accidents are accidents. They just happen. They cannot be caused or prevented.
2. We prevent accidents because it is our legal duty.
3. Productivity is more important than safety.
4. Safety obstructs productivity OR Safety retards production.
5. Safety and productivity are two sides of a coin.
6. Legally 'accident' is not possible without injury.
7. ‘Accident is also possible without injury or damage.
8. Prevention of near miss is more important than to prevent 'accident'.
9. Heinrich’s ratio theory is meaningless. Accident does not give any warning or opportunity to prevent it.
10. 88% accidents occur due to unsafe acts of the workers. Therefore there is no meaning in wasting money to improve ‘unsafe conditions’.

11. Accident happens due to multiple causes, not by any single cause.
12. Energy transfer is the main cause of accident.

13 Organisation is the first step of accident prevention.
14. In accident prevention work, search of ‘past facts’ (accident record) and ‘future facts’
15. ‘Engineering control’ is the best remedy.
16. Without application of the remedy, other efforts are helpless.
17. All accident prevention work is basically educational.
18. Reactive approach is preferable to proactive approach.
19. Supervisor should 'talk to' the worker and not 'talk with' the worker to explain his unsafe act.
20. Feedback or measurement of result is useful in 'performance cycle model' to correct our preventive action.

2. Write Short Notes OR Explain in brief:

1. The accident problem.
2. Need for safety.
3. Reasons for accident prevention.
4. Factors impeding safety.
5. Meanings of 'Accident'.
6. Types of 'Accident'.
7. Types of Injury'
8. Types of 'Dangerous occurrences'.
9. Types of 'Dangerous operations'.
10. Types of 'Hazardous process'.
11. Notifiable diseases.
12. Ten Axioms of industrial safety.
13. Accident sequence.
14. Criticism of Heinrich's theory.
15. Facts finding for accident prevention.
16. 'Unsafe acts' OR 'unsafe conditions'.
17. Four basic remedies for accident prevention.
18. Ways and means to apply remedy to prevent accidents.
19. Updated Safety Management Model.
20. Two approaches to safety.

3. Discuss with details:

1. H.W. Heinrich's Theory OR Frank Bird's Domino Theory.
2. Multiple Causation Theory OR William Hadden's Energy Theory.
3. Five Fundamentals of Accident Prevention.
4. Five 'E's of Accident Prevention.

Reference and Recommended Readings

1. Industrial Accident Prevention, H. W. Heinrich, McGraw-Hill.
2. Safety and Health for Engineers, Roger L. Brauer, Van Nostrand Reinhold, New York.
3. The Factories Act 1948 and the Gujarat Factories Rules 1963 with subsequent Amendments.
4. The Workmen's Compensation Act 1923 and Rules 1924.
5. Accident Prevention Manual for Industrial Operations, National Safety Council, USA.
6. Techniques of Safety Management by Dan Prederson.
7. Beyond Human Error : Taxonomies and Safety Science. By Brendan Wallace and Alastair Ross.
8. Human Error : Causes and. Control by George A. Peters and Barbara J.Peters.
9. The Blame Machine ;Why Human Error Causes Accidents By. R. B. Whitingham.
10. Accident prevention : A. worker's education manual second (revised) edition.

CHAPTER – 5

Safety Statistics and Information System

THEME

1. NATURE, SOURCE AND NEED OF STATISTICS OF SAFETY

Nature:

'Statistics of safety' is a wider term expecting many data. Mostly it includes 'accident statistics' and 'costs of accidents', but it may also include measurement of safety performance and labour turnover, safety activity rate, cost of accident prevention and modern approach to measure the problems of safety. The cost of accident includes a variety of direct and indirect costs which emphasise the need of safety. An accident is a great loss to the person injured, his family, his employer or factory and tile society at large. How to measure all such losses is a real problem of statistics oLs&fety.lS:3786-1983 prescribes some methods of computation.

Source :

At present the major source of our labour statistics is the Labour Bureau, Shimla, which is the main body under the Ministry of Labour, Govt of India compiling and publishing various labour statistics of India through its many publications. It regularly conducts training classes to teach such statistics which is highly useful to all labour and safety people. Other agencies are National Safety Council and Central Labour Institute, Mumbai and Offices of the Labour Commissioners and Factory Inspectorates of all States and Union Territories. Some Industrial Extension Bureau such as INDEXTb in Ahmedabad also publishes good statistical reports. Figures and Tables given in this Chapter are taken from the publications of these sources. .Statistics of road-and other accident can be had from police and transport offices.

NOW a days websites are also available.

Need or Utility of Data:

Why do we need safety statistics or measurement of safety performance? This basic question has following basic replies :

1. It is the basic force of the organised safety movement
2. It is useful to all management to calculate their accidents costs. The management must realise that indirect (hidden) cost of an accident is 4 to 8 times more than the direct cost. This cost saving factor can motivate them for prevention of accidents, injuries and property losses.
3. The statistics is useful in comparing ourselves with others in relation to safety records. This leads us to better safety performance and safety records.
4. It properly emphasises that accident prevention is economical and productive rather than humanitarian.
5. It promotes safety in all walks of life like road safety, home safety, industrial safety and safety at the sea and the sky.
6. It equally opens the eyes of workers and their unions in really understanding their accident problems and losses to them. Actually, the workers are the first and most sufferers of accidents or injuries the statistics of which explains them the importance and gravity of the problem.
7. The Government is paying lakhs of rupees every year in terms of workmen compensation and other benefits. Many insurance companies also pay the huge amount for accidental injuries, deaths and property- damage. If they know the real statistics of accidents or losses, they may try to suggest necessary safety measures to reduce the premium amount.
8. Reliable cost information is* A basis for decisions upon which efficiency and profit depend. Some proposed measures may be accepted or rejected on the basis of their probable effect on profits.
9. Most executives wish to make their companies safe places and run their business profitably. Information on the cost of accidents enable them to estimate the savings which can be effected through investment for accident prevention.
10. Monthly reports showing the cost of accidents or the savings due to good accident prevention efforts is an important means of motivating attention to safe operating conditions and procedures.
11. Accident statistics give clear classification that what are the main causes of accidents, which are the main departments of accidents, what are unsafe areas or conditions, what are unsafe actions, how much is the money-loss and time loss in accidents etc., so that we can easily concentrate upon those areas and provide remedial measures to stop those losses. This is the greatest advantage of safety statistics.
12. The altitudes of workmen and of society become unfavourable when accidents are frequent or. affecting public at large as in case of Bhopal disaster. An unfavourable attitude invariably influences production, sales etc. The realisation of such indirect costs or public compensation serves as motivation for management to prevent accidents. It is also a warning to the unsafe

13. Safety statistics shows the need and methods for standardised data about accidents, injuries, failure rates of equipment etc. and costs. Indian Standard IS:3786 provides method for computation of frequency .and severity rates for industrial injuries and classification of industrial accidents. The statistics is also useful in preparing, presenting and communicating reports on safety performance.

14. Accident statistics provide valuable information to regulatory agencies and insurance companies. Regulatory agencies may use such data to identify causative factors and additional safety requirements to prevent future accidents. Insurance companies can use the data in determining costs of premiums which are based on accident and injury frequencies and severity rates.

15. Accident statistics are essential for planning accident-prevention activities, assessing their effectiveness and amendment of safety laws.

2. MAGNITUDE OF THE PROBLEM AND INADEQUACY (LIMITATION) OF DATA

Let us try to understand the problem by some available data:

India :

In our .country, in 1994, there were total 190435 accidental deaths (See Table 5.7) of which majority were road and rail accidents and due to fire, drowning, poisoning and miscellaneous causes. The factories and mines accidents were 606 and 506 respectively. Percentage wise major causes-were: Road accident 27.2, Fire 12.2, Drowning 12.1, Railway accident 9.6, Poisoning 7.2, fall from height 12, Electrocution 1.8, others 9.2 and unspecified causes 18.5. This is shown in Fig. 5.1. Almost similar are the figures for 1993 and 1992 (LP News, 1996). Thus fatal industrial accidents are less than 1% of the total accidents in the country.

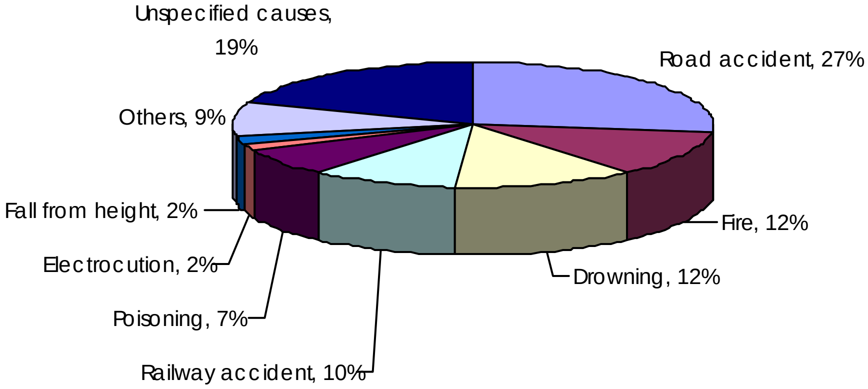


Fig. 5.1 : Fatal accidents in 1994

In 1990, there were total 663 fatal and 127454 non-fatal factory accidents in India, which were 784 and 253184 in 1986, respectively.

Under the Workmen's Compensation Act, in 1992, there were 1503 deaths, 1365 permanent disablement 7377 temporary disablement reported land amount of compensation paid for them were Rs. 807.43 lakhs, 233.36 lakhs and 113.55 lakhs respectively.

Under the Employees' State Insurance Act, in 1992-93, the figures areas follows :

No. of factories covered	150349
No. of employees in factories covered	6691000

No. of family units covered	7444000
No. of beneficiaries covered	28883000
No. of cases admitted in hospitals	3777904
Home visits paid	184148
Medical benefits paid (total)	Rs. 8329 Lakhs
Dependants benefits paid	Rs. 1211 Lakhs

Above figures are not the complete picture, because, many accidents might not be reported and many factories are not covered under the ESI Act.

UK:

As per the Robens Report, the figures of 1969 were as follows:

Subject	Number	Cost Million Pound
Fatalities in industries	1918	20.20
Fatalities in factories	649	8.28
Industrial accidents	841680	96.90
Factory accidents	441630	54.70
Total industrial accident cost		336.30
Total factory accident cost		133.90

USA:

In 1965, the total cost of accidents at work, home and roads was estimated 18030 million dollars.

The National Safety Council estimates that the annual costs resulting from injuries and deaths plus losses in motor vehicle mishaps and fires, are @50 billion dollars. This is too incomplete and far too low a figure for all accidents.

As per the NSC report of 1963, the annual accident toll in USA was estimated at 100500 deaths, 2 x 10" disabling injuries and total economic loss 53 x 10« dollars.

H. M. Vernon estimated the loss in potential production through industrial injuries amounted to 643 x W dollars in 1932.

As per another report, yearly accidents in USA are @ 3 x 10^6 of which industrial accidents at work are believed to be 9 x 10^5 costing 6 x 10^8 dollars and involving 24 x 10^6 man days lost

As per Accident Facts, 1997, NSC, USA, unintentional injury deaths were estimated 93400 in 1996, each year @2.6 million Americans were hospitalised for injuries, @39.6 million were treated in hospital emergency departments and @60.5 million (nearly one in four) required medical attention or suffered at least a day of activity restriction from an injury.

The economic impact of above fatal and nonfatal injuries amounted to $444.1 billion in 1996. This is @ $1700 per capita, or @ $4500 per household.

Such human and economic costs add up to staggering totals, and make it obvious that a major effort to lessen them is in order. Because of the magnitude of this accident problem, all factories should set up safety programmes of various types to deal with the problem.

International Comparison: The industrial (manufacturing) Accident Rates per one million man hours worked in 1990 of some countries are as follows :

Egypt	0.13	Japan	0.01
Tunisia	0.07	Germany	0.07
Poland	0.05	UK	0.02
USA	0.02	New Zealand	0.04
France	0.06	Philippines	0.05
India	0.20		

Thus we have comparatively the highest accident rate.

Inadequacy or Limitations of Data :

It is believed that safety statistics is under reported. Majority of unregistered factories, small factories and industries do not report all cases of accidents, occupational diseases and poisoning, nor do they maintain any record.

See Table 5.2 and footnote under it. Indian Labour Statistics 1991-93, published on 29-5-1995 by Labour Bureau,. Shimla, could accommodate statistics up to 1992 and as mentioned under the foot-note, many States (more than ten) did not send information of industrial injuries for the years from 1984 to 1991. In Table 9.2 on Maternity Benefit paid under the M. B. Act, 1961, it is revealed that 20 States (out of 24) did not send complete information for the years from 1988 to 1992. Gujarat had sent information for one year (1989) only and that too incomplete! This is the situation in many statistical tables. This indicates limitation or inadequacy of data. The main reasons are well-known and as under

1. Lacs of small and medium scale industries are' out of coverage to fill 'returns' for safety information.

2. Lacs of factories may be unregistered due to whatsoever reasons. The result is that, no information is available from them on the matters of **safety, health, welfare** and environment .

3. Thousands of registered factories do not send prescribed 'returns' or necessary statistical information.

4. As the States do not get information from industries, they are unable to send it to the Labour Bureau, Shimla.

5. Even in information available or sent, many are incomplete or do not tally with others.

6. Compilation at every stage takes too much time (years) and causes great delay.

7. Compilation at National level and publication needs further time and results in. delay. Interest and efforts at all levels are necessary to solve this problem.

8. Information on cost of accident is rarely available. A few big factories may be keeping the records of direct and indirect costs of accidents.

9. The cost of loss to the families and society is hardly available.

10. All industries are not covered under the ESI Act and the figures of compensation under this Act and the Workmen's Compensation Act do not give an all-India picture.

11. No record of private medical expenses is traceable from one source.

12. No record of accident expenditures in agriculture, at homes, at shops, stores, roads, godowns and other workplaces is available.

This suggests some forms to be prescribed for such records at such places. Only then we can have the real and full picture of all accidents in the country. How to make this possible is another problem to be tackled by national institutions.

Costing or valuation of material damage or losses is possible, but, how do we value a human life? Can any meaningful price (cost) be assigned to it? How can anyone equate the value of 2500 lives (of Bhopal accident) in terms of cash equivalent ? And how to value the after-effects on impaired parts of the bodies? or after-effects of emotional pains to families? This is all very difficult and therefore, only estimation is possible. This is again an inadequacy or limitations of safety data.

It is interesting to note that Melinek S. J. suggested a method of evaluating human life for economic purposes and he concluded in 1972 the value of human life was about 50000 pounds (this can become many times more at present). He added that there is a large difference between the value people place on their own lives and the value placed on them by society at large, which is usually much lower.

3. ACCIDENT COST TO THE INJURED PERSON AND HIS FAMILY .

Accidents are costly to the injured person, to his family, to the management and to the society. Let us see how much an injured worker would lose due to an accident to him.

In addition to pain, suffering, worries, incapacity, wage .loss, medical and other expenses, he also suffers as under.

If a worker is not covered by any insurance scheme, he has to bear the loss of wages and the cost of medical expenses, transport, fruits, food etc. If he suffers permanent disablement, he loses his earning capacity for life.

If a worker is insured under any scheme, he gets some compensation, medical expenses and some daily allowance which are hardly adequate. No costing is possible for his suffering, pain, worry and incapacitation. Even after return to duty, he is unable to perform his normal work for many days and therefore may lose incentive and overtime wages during that period. Another loss is his mental setback and inability to social functions and recreation.

Example :

Let us take an example of a worker who meets with an accident at his age of 20 years and loses his total earning capacity. His monthly wage is Rs. 1500/-.

As per Workmen's Compensation Act, he will get (60% of 1500) x the relevant factor
= 900 x 224 = 201600, or Rs. 90000/- whichever is more, thus he will get the compensation of Rs. 201600/-.

If the accident would not have happened, he would have worked for another 40 years and would have earned as follows :

1500 p.m. wage x 12 months x 40 years

= 720000.

Considering yearly increment of Rs. 50 throughout the span of 40 years, i.e. increasing Rs. 50 x 12 = 600 each year for 40 years (wage ceiling is not considered because of the periodical wage rise), further earning

= (600 x 1) + (600 x 2) + (600 x 3)+.... (600 x 40)
= 600 (1+2+3+......+40) = 600 x 820 =492000

Therefore total earning = 720000 + 492000
= 1212000.

Thus against Rs. 1212000 he gets only Rs. 201600 which seems much less.

Suppose, he would have died, his family gets (50% of 1500) x the relevant factor = 750 x 224 = 168000, or Rs. 80,000 whichever is more, i.e. Rs. 168000 a still less amount than the compensation for permanent total disablement.

4. ACCIDENT COST TO THE MANAGEMENT

Management suffers two types of costs

1. Direct or Insured or Tangible Costs and
2. Indirect or Uninsured or Intangible (hidden Costs. -

4.1 Direct Costs:

This includes the compensation paid to the injured person, or insurance premium, medical and hospital charges, transport charges directly paid by the employer.

Direct costs are easy to calculate as their money value is directly available. Workers' legal compensation or accident insurance premiums (net premiums after deducting refund if any), medical expenses of doctors' bills, medicine bills, hospital/ dispensary charges etc., extra compensation paid to the injured worker or his family and all other direct expenses/expenditures paid, by the employer due to the accident, constitute direct costs.

If hospital charges' doctor's bill, medicine bill or other expenditure is paid by insurance company, only premium cost should be considered. Direct cost includes insured expenditure and direct payment only.

4.2 Indirect Costs :

Indirect costs are of many types and need careful consideration to determine their 'equivalent money value'. Use of cost data sheets and other methods have been developed to calculate indirect costs. They include following

1. Cost of wages paid for working time lost by insured workers, other than workers' compensation payments.

2. Cost of wages paid for working time lost by workers, other than the injured worker(s).

3. The net cost to repair, or replace material or equipment that was damaged in accident.

4. Extra cost due to overtime work necessitated by accident.

5. Cost of wages paid to supervisors for their time required for activities necessitated by accident.

6. Wage cost due to decreased output of injured worker after return to work.

7. Cost of learning period and preparation of new worker(s).

8. Uninsured medical cost borne by the company.

9. Cost of time spent by higher officers, outsiders and clerical workers on investigations or in restarting the production or in processing compensation application, procedure and other administration.

10. Cost of work interruption due to idle machine, work stoppage or spoilage.

11. Cost of property (including material and equipment) damage due to accident.

12. Uninsured other costs and the miscellaneous unusual costs.

The ratio 4 to 1 : In 1927, **H. W. Heinrich** presented a paper at the National Safety Congress (USA), and placed the indirect cost as an average 4 times the direct cost. This was the origin of much discussed and controversial 4 to I ratio.

Some studies yielded ratios ranging from 8 to I to I to I, but, in general, they supported Heinrich's findings.

Heinrich writes, 'It is not contended that the 4 to I proportion holds true for every industrial accident or every individual plant, and it is granted that in nation wide application the ratio may vary, yet it has already tested sufficiently to provide approximate confirmation'.

After Heinrich's research of 4 to I ratio in 1926, much discussion was carried out. Frank E Bird, Jr., accepted the iceberg principle of hidden costs, dividing them into two categories: uninsured costs of property damage which can be easily quantified and uninsured miscellaneous costs which are difficult to quantify. His estimates of each are higher than original 4 to 1 estimate as shown in Fig. 5.2

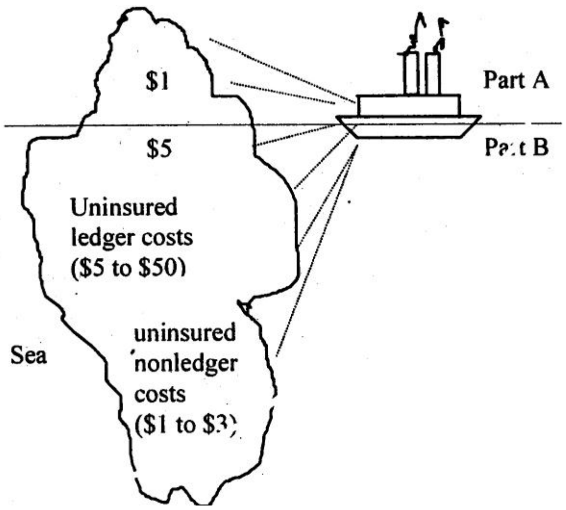


Fig. 5.2 : Bird's Iceberg concept

Part A : Insured costs

1. Medical 2. Compensation

Part- B : Uninsured costs

1. Building damage
2. Tool & equipment damage
3. Product & material damage
4. Production delays & interruptions
5. Many items such as hiring & training, investigation time etc.

Simonds and Grimaldi use the terms 'insured' and 'uninsured' for Heinrich's terms 'direct' and 'indirect' and state that (1) Heinrich's ratio '4 to I' is higher because some of the uninsured (indirect) costs included by Heinrich are not valid and (2) There is no direct correlation between insured (direct) and uninsured (indirect) costs and applying a single ratio gives inaccurate results. They give the following formula –

Total cost =	Insurance cost (i.e. direct cost)	
	+ A x No. of	lost time cases
	+ B x No. of	doctor's cases (no lost time)
	+ C x No. of	Only first-aid cases
	+D x No. of	accidents causing no injuries but causing property damage in excess of specified amounts,

where A, B, C, D are the average uninsured (indirect) costs for each category of cases, and the number of cases refers to the actual count of each type during the period under consideration.

Bird and Germain, however consider this revised concept, an ineffective tool in safety motivation and they suggested, a ledger-costs concept that appear on department ledgers. The main factors considered in accident cost-accounting are -

1. Workers:
   (a) Total cost of workers' compensation benefits.
   (b) Wages and medical costs paid during disability in addition to (a) above.
   (c) Cost of time lost on day of accident and on subsequent days.
   (d) Cost of time spent on light work or reduced output.

2. Machinery, Material, Equipment :
   (a) Cost of repairing damage or cost of replacement.
   (b) Cost of lost production time,

Despite their differences, Heinrich, Simonds and Grimaldi, and Bird and Germain all agree that accident costs tend to be underestimated.

By formula or ledger, total cost calculation does not explain difference between direct and indirect costs, or their ratio, as they are explained by Heinrich's concept (breakup) and ratio.

Factors of Indirect (Hidden) Accident Cost:

The list given by Heinrich is as under :

1. Cost of time lost by injured employee.
2. Cost of time lost by other employees who stop work.
   a. Out of curiosity.
   b. Out of sympathy.
   c. To assist injured employee.
   d. For other reasons.

3. Cost of time lost by foremen, supervisors or other executives as follows:
   a. Assisting injured employee.
   b. Investigating the cause of the accident.

   c. Arranging for the injured employee's production to be continued by some other employee.
   d. Selecting, training, or breaking in a new employee to replace the injured employee.
   e. Preparing statutory accident reports, or attending hearings before Govt. officials.

4. Cost of time spent on the case by first-aid attendant and hospital department staff, when not paid for by the insurance carrier.

5. Cost due to damage to the machine, tools, or. other property or to the spoilage of material.

6. Incidental cost due to interference with production, failure to fulfill orders in time, loss of bonuses, payment of forfeits and other similar causes.

7. Cost to employer under employee welfare and benefit systems.

8. Cost to employer in continuing the wages of the injured employee in full, after his return - even though the services of the employee (who is not yet fully recovered) may for a time l)e worth only about half of their normal value.

9. Cost due to the loss of profit on the injured employee's productivity and on idle machines.

10. Cost that occurs in consequence of the excitement or weakened morale due to the accident. (Stoppage or slawing down of work)

11. Overhead cost per injured employee - the expense of light, heat, rent, and other such items, which continues while the injured employee is a non-producer.

This list is not exhaustive and many points can be added to it, though it is sufficient to point out unexpected loss producing events that follow the consequence of accident.

Ratio Relationship : The following table shows the ratio relationship between these costs in some countries.

Country	Year	Direct Cost	Indirect Cost
UK	1967	1	6.7
USA	1932	1	8
Germany	1954	1	10.7
Austria	1965	1	6.4

In India, such record is not available, but it can be roughly estimated to be 1:3 to 1:8.

Example :

Let us consider an example of a worker drawing Rs. 900/- p.m. and meeting with an accident at his age of 40 (completed) and losing three fingers of one hand (i.e. 30% permanent partial disablement).

Direct Cost (Rs.)

1.	Compensation under Workmen's Compensation Act. From Sr. No. 8 of Part II of Schedule I, 30% of (60% of 900 x the age factor) = 0.30 (540 x 184.17) = 0.30 x 99451.8	=	29835
2.	Medical & Hospital charges including fees, medicines, milk, fruits etc.	=	02137
3.	Transportation charges	=	00200
	Total direct cost Rs.		32172

Indirect Cost (Rs.)

1.	Cost of lost time -		
	A.	By injured worker	1870
	B.	By other workers	5330
	C.	By Supervisors & executives	6240
	D.	By first-aid staff and Clerical expense	1260
2.	Cost of production loss due to -		
	A.	Idle m/c and clean up etc.	1390
	B.	Damage to the machine	7310
	C.	Damage to tools	5650
	D.	Damage to materials	4620
	E.	Spoilage of materials	2550
3.	Incidental cost due to -		
	A.	Fulfilling order (supply) in time (worked overtime)	6280
	B.	Payment of forfeits	
	C.	Welfare & benefit system	0840
	D.	Less production by the injured worker after his return to work	8560
	E.	Loss of profit & productivity	5356
	F.	Production loss by weakened morale of others	2644
4.	Overhead & Administrative expense		4800

Total indirect (uninsured) Cost	64700
Total cost of the Accident 32172 + 64700 =	96872

Here the ratio comes to @ 1:2, but, this is widely variable depending upon each case.

Suppose due to a fatal accident 3500 workers do not work for one shift or day, that estimate only would cost Rs. 3500 x 60 (daily wage) = 210000 and adding to the indirect cost, the ratio would be 1:8.

Suppose direct cost is not born by the company which paid accident insurance amount for that-worker as Rs. 16000, then ratio will become 16200/64700=l:4. See also Part 4 for costs discussion.

See Part 5 & 7 of Chapter-29 for legal provisions.

5. UTILITY AND LIMITATION OF COST DATA

Data of accident costs are many difficult to get and they have limitation also. But they are most useful to convince tile management to plan and work for safety.

5.1 Utility (Usefulness) of Cost Data to Convience Management:

Direct cost of accident is directly available and is very much useful to calculate expenditure and budgetary estimate on -predictable accidents or fire / explosion and other risks.

Indirect costs are also real costs and they should be calculated to quantify or demonstrate in meaningful way. Such unproven costs may seem unreal to the management and it may not be convinced. However Safety Officer should try to quantify these hidden costs, to explain the iceburg concept (Fig. 5.1) to the management and to draw a conclusion that 'preventive costs may be less than the total costs of accidents' - a powerful stimulus for the management to invest for accident prevention' work.

Each industry should try to calculate accident costs of all the accidents happened in last (completed) year and to compare the ratio year to year. This will indicate where and how we can reduce the accident costs. The best effort was made by Godrej and Boyce Mfg. Co. Ltd., Mumbai by preparing an impressive book on such accident costs studies and also showing by an exhibition.

There is a great significance of this ratio of costs to statisticians, employers, employees, safety officers and insurance salesmen. It supplies powerful stimulus to convince management for preventive action. It emphasises that - ,

1. Cost estimates may remain underestimated and the million - rupees may be increased 4 to 5 times.
2. The employers must worry about accident cost and accept accident prevention as their economic activity and duty.
3. The work of safety officer has a real monetary value and
4. It enhances the value of the service of an insurance salesman.

5.2 Limitation of Costs Data:

Limitation (inadequacy) of accident data is discussed in Part-2. Direct (insured) and indirect (uninsured) costs of various types are discussed in Part-4. From this discussion it is inferred that the data of direct cost is easily available as insurance premiums or direct compensation costs or other medical and safety expenditure from records.

It is the indirect (uninsured) and other intangible costs which are not directly available and are to be calculated from other data. Such points mentioned in Part- 4 show the limitation of cost of data.

Except a very few companies, hardly data is available on cost of time spent by the injured worker due to accident, time spent by co-workers, supervisors and others in inquiring or investigating that accident, time spent by idle machine or interruption or production loss, money value of repair or replacement, money value of delay in fulfilling orders, money value in preparing a substitute, cost of damage to public or public liability claims, loss of profit due to cancelled contracts or orders or rejects, cost of excess spoilage by new employees and demurrage etc. Cost of damage to environment and cost of court penalties due to accident cases are also unpredictable. This indicates the limitation of cost data.

6. ACCIDENT SOCIETY COSTS TO THE

The society suffers losses in three ways :

1. The family - a part of the nearest society suffers pain, financial hardship and service or maintenance loss by the injured person or his death.
2. The society 'as consumers pay the increased cost of production due to direct and indirect cost to the management.
3. The society bears the social and financial burden of maintenance of all injured persons and their families. Thus knowingly or unknowingly every member of the society bears a proportion of the costs of accidents, and
4. The society losses service or help by that person.

Therefore employee, employers and society all have to work collectively for accident prevention.

7. COST COMPILATION PROCEDURE

Following examples illustrate the cost compilation procedure.

Example :

A worker dies in an accident at his age of 55 when he was drawing Rs. 6600/- p.m. He was very experienced worker and leader of the factory of 3650 workers. If he would have not died, he would have worked another 5 years. Calculate the cost of this accident to his family, his management, the society and the overall cost totalling all the three factors.

(1) Cost to the family :

As per the Workmen's Compensation Act, Section 4(1) (a) and Explanation, his family will get 50% of 2000 x the relevant factor = 0.50 x 2000 x 135.56 = Rs. 135560.

If he would have not died and worked for further five years, he would have earned 6600: x 12 x 5 = Rs. 396000. Considering yearly increment of Rs. 50 throughout the span of 5 years, increasing Rs. 50 x 12 == 600 each year for 5 years, he would have further earned

= (600 x 1) + (600 x 2) + ... + (600 x 5)
= 600 (1+2+3+4+5) = 600 x 15 = 9,000.

Therefore his total earning would have been Rs. 396000 + 9000 = 405000.

Deducting the compensation received, cost (monetary) of accident to his family

= 405000 - 135560 = Rs. 269440 ....(1)

The cost of the person lost is intangible.

(2) **Cost to the Management (Estimates) :**

		Rs.
(A)	**Direct Cost**	
1.	Compensation under W. C. Act	135560
2.	Medical & Hospital Charges	000750
3.	Transportation Charges	000690
	Total Direct Cost	137000
(B)	**Indirect Cost**	
1.	Cost of time lost by	
	a. Injured worker (including extra payments)	----
	b. Other workers	012744
	c. Supervisors & executives	016423
	d. First-aid staff and clerical expense	001077
2.	Cost of production loss due to	
	a. Idle m/c and clean up etc.	008375
	b. Damage to the machine	002125
	c. Damage to tools/equipment	000412
	d. Damage to materials	001188
	e. Spoilage of materials	000200
3.	Incidental cost due to	
	a. Fulfilling order in time (required overtime)	001682
	b. Payment of forfeits	---
	c. Welfare & benefit system	002318
	d. Loss due to preparing substitute	008256
	e. Loss of profit & productivity	011944
	f. Loss of production by weakened morale of others	033689
	g. Wage& production loss by half day work-stoppage by all workers' 0.5 x 60 x 3650=	109500
4.	Overhead and Administrative	020311
	Total indirect cost	230244

The ratio D. C. : 1. C. = 137 : 230 = 1: 1.7

If the direct cost is insured by some insurance agency and if we consider the annual insurance premium as Rs. 40000, the direct cost would be Rs. 40000 and the ratio, then will be 40:230 = 1:6.

The total cost to the management = 137000 + 230244 == 367244, if uninsured, and 40000+230244=270244, if insured .....(2)

Thus, insurance saves cost of accident.

(3) Cost to the Society (Estimated) :

(A)	Loss to his family, other than the wage loss (in the form of other services)	55800
(B)	20000 consumers pay the product price rise assuming Rs. 2 each, then	40000
(C)	Social and financial help by the society	04200
	Cost to the society	Rs. 100000

… (3)

Therefore the overall (national) cost totaling above three factors

= (1)+(2)+(3) = 269440 + 367244 + 100000 -Rs. 736684

Thus one fatal accident costs to the nation in lakhs of rupees.

Estimating minimum cost of fatal accident as Rs. 1 lakh and @ 1800 fatal accidents in factories in India per year, the minimum total cost of all these accidents would be 1800 lakhs rupees, and estimating @ 120000 total fatalities (of all kind), their total national cost would be Rs. 120000 x 100000 = 12×10^9. What a great target (and cause) for all safety people to minimise this national annual loss !

8. CRAIG SINCLAIR'S STUDY OF ACCIDENT COST, PREVENTIVE COST AND THEIR RELATIONSHIP

T. Craig Sinclair on behalf of the Robens Committee on Health and Safety carried out a detailed study and published a paper 'A cost effectiveness approach to individual safety, HMSO London, (1972)'. A brief summary of his concept is given below :

*

Estimate of Accident Costs :

The costs of accidental injuries are made up of three parts - fatalities, serious injuries (over 4 weeks off work) and other injuries. Thus we can write.

AC = RD (ASd + AOd) +RS (ASs + AOs) + RO (ASo + AOo) Where

AC = annual Accident Cost per worker
RD = annual Risk of Death per worker
RS = annual Risk of Serious injury per worker
RO = annual Risk of Other injury per worker
AS = Subjective element of cost and
AO = Objective element of cost with second subscript d, s or o for death, serious injury and other injury.

Sinclair has applied this method with meaningful results to large groups of workers in entire industries including agriculture. The method is not useful for very small groups where the resuite will have little statistical significance.

9. FORMS OF ACCIDENT STATISTICS

Three forms for useful accident statistics are suggested as under:

9.1 Accident Report Form:

An internal accident report form should be devised to contain facts as under:

1. Statutory information (say. Form No. 21, 21-A and 22 under the Gujarat Factories Rules).
   a) Name, Address, Phone arid Fax No. of the Factory.
   b) Name, Address, Phone and Fax No. of the Occupier. .
   c) Name, Age, Sex and Address of the Injured or Died Person.
   d) Experience, training, qualification etc.
   e) Place, Date, Time, Shift and Type (Fatal, Nonfatal, Serious etc.) of the Accident or Dangerous Occurrence.
   f) Nature, Type, Extent and Body part of Injury, Poisoning or Disease.
   g) The severity of injury in details, Short mention like fatal, non-fatal, abrasion, etc., are insufficient.
   h) Doctor and Medical Staff who attended the Victim.

2. All causes - immediate and contributing - of accident. Possible detail should be given.

3. Nature of job and exact work being done by the injured worker at the time of accident.

4. Psychological data with previous accident history, if any.

5. Physiological factors and bodily defects or habits, if any.

6. Physical conditions - work load, physical, mechanical, chemical and environmental factors present at that time.

7. Names, Addresses and Statements of co-workers and witnesses who saw the accident.

8. Proofs, evidences, photographs, records, register etc. to understand the cause(s) of the accident.

9. Remedial measures
   a) Immediately required to prevent the recurrence.
   b) Required as second phase of compliance.

10. Any other relevant information pertaining to above accident.

Name and Signature of Supervisor __________
Safety manager______
Plant incharge _______

Then from this internal accident report, required statutory form should be filled in.

9.2 Accident Investigation Form:

A specimen form is devised and given below to keep a good record, of accident statistics. It is useful for costing and classification of individual accident to conclude sharply for its prevention. Information is to be given by the Dept. concerned and to be maintained for internal safety audit.

Name & Address of the Factory or Industry :
Type of Manufacturing Process :
Industrial Classification :
Total workers _________ Shifts _________ H.P. _________

(A) Supervisor's Report

1. Injured person's (a) Name & Address ______________________________
   (b) Employee Code No. ________ (c) Department _________ .
   (d) Age (years completed) _______ (e) Sex _____ .
   (f) Occupation/Designation __________________________________

2. Date & Time of the Accident _________________________________

3. Place and Department of Accident ____

4. When did the injured person start his work in this place?

5. Causation Analysis :
   (a) Caused by machinery? (Yes/No) _________
   Give name of the machine, H.P., its part causing the accident, whether it was moved by power, description of the process/operation going on and what the injured person was exactly doing at that time.
   (b) If caused by another person's fault, give its details.
   (c) Names and addresses of co-workers and witnesses who actually saw the accident or knew about it.
   (d) Nature and type of accident.
   Nature : Fatal? ______ Statutorily Reportable? ________ Causing Injury? (i.e. disabling or lost-time) ______ Causing no injury but property damage only? _____ Other type _______
   (e) Nature, extent and description of injury.
   (f) Supervisor's exact opinion about the direct and indirect cause, whether it was due to unsafe condition or action or their combination and actual reasons with facts.

(B) Medical Department's Report :

1. Description of injury in details (Nature & Extent).
2. Description of permanent health effect if any.
3. Description of the First-Aid (including antidote) given.
4. Description of after treatment.
5. Date of found fit to resume duty (Mention subsequently)
6. Name of Doctors /Medical Staff who gave the treatment.
7. Cost of total medical expenses.
8. Cost of extra hours worked by the doctor and his staff due to this accident.

(C) HR/ Personnel Department's Report:

1. Injured person's (a) Date of Joining ______ (b) Date of Birth _____ (c) Qualification __________
   (d) changes of Departments ________ (e) Training & Experience (f) Monthly wage Rs. _______
   (g) Hourly wage Rs. _______ (h) Name & Address of near relative to be informed immediately

2. Date of resuming duty _________. and Man-days lost _______
3. Amount of accident insurance premium for the worker _______
4. Amount of Compensation paid/payable ______ and by whom _________.
5. Other amount (eg. extra componsation) paid to the injured person or/and his family

(D) Safety Department's Report:

1. Date of investigation started _______ by whom ______________________
2. Names and Designation of investigating officer(s) _____________________
3. Date of investigation completed _____________
4. Concluded causes of the accident (Give details) :
   (a) Unsafe condition (main) ?
   (b) Unsafe action (main) ?
   (c) Their combination or multiple causes ?
   (d) Psychological factors ?
   (e) Physiological factors ?
   (f) Environmental factors ?
   (g) Physical conditions or work load ?
   (h) Description of the cause(s).
5. Classification of the Accident.
6. Remedial Safety Measures.
   (a) List of total measures suggested in order of priority.
   (b) List of measures already complied with. ,
   (c) List of measures yet to be complied, within what time and by whom

Date :

Signature of the
Manager or Occupier

9.3 Accident Costs Form

1. Name & Address of the Factory/Industry ____
2. Name & Address of the injured person _________________________Employee/Code No ______
3. Type of injury _________ (Death, permanent total disablement, permanent partial disablement, temporary disablement)
4. Nature of injury (body effect) _____________
5. Date & Time of Accident _______________ Place of Accident _______
6. Department ___________ Process/operation ___________
7. Hourly wage of the injured person _______
   Hourly wage of the supervisor ______
   Hourly wage of the workers and other officers who left their work and spent their time for the accident (i) (ii) (iii) (iv) (v)
8. Direct Cost Computation. Rs.
   (a) Amount directly paid by the company as Compensation or any premium or contribution under the W. C. Act or ESI Act or any Insurance Scheme for the Worker _______
   (b) Medical and Hospital Charges _______
   (c) Transportation Charges for Medical treatment _______
   (d) Extra Compensation or Help to the injured worker or his family members including payment of wages given during the period of absence due to the accident and not adjusted' against the amount of compensation, including any amount paid in whatsoever name _______

   Total Direct Cost (DC) Rs. _______

9. Indirect Cost Computation.

Time (hours) spent by the injured person and others as in 7 above.

(i) (ii) (iii) (iv) (v)

			Rs.
(1)	Therefore cost of time lost by		
	(a)	Injured worker	__
	(b)	Other workers	__
	(c)	Supervisors, Officers and Executives	__
	(d)	First-aid and clerical staff	__
	(e)	Outside agency (viz. Safety Consultant)	__
	(f)	Other persons	__
(2)	Cost of material and production loss due to		
	(a)	Spoilage of materials	__
	(b)	Damage to materials	__
	(c)	Damage to machine/vessels	__
	(d)	Damage to tools/equipment	__
	(e)	Idle m/c and clean up, repair etc.	__
	(f)	Other damage and repairs	__
(3)	Incidental cost due to		
	(a)	Extra work for fulfilling the order in time (required overtime payment)	__
	(b)	Payment of forfeits	__
	(c)	Welfare and benefit system	__
	(d)	Preparing or hiring substitute	__
	(e)	Decreased output (production) by the injured and others for some time	__
	(f)	Wages and production loss due to mass work-stoppage by workers	__
	(g)	Overhead and Administrative expense	__
	(h)	Loss of profit and productivity	__
	(i)	Amount not classified elsewhere	__
		Total Indirect Cost (IC) Rs.	__

10. The Ratio of IC to DC (Total of item 9/Total of item 8) __
11. Cost of accident to the management = Total of item 8+Total of item 9 __
12. Cost of accident to injured person's family __
13. Total cost of accident = 11+12 __
14. Estimate of Preventive costs __

Signature of Occupier / Manager.

In our country such accident and cost forms are not maintained by industries in respect of all accidents. In want of them, exact causation, preventive measures B - cost of accident cannot be determined in details. Therefore such forms (or modified as per own requirement) should be voluntarily maintained by all industries for the purpose of precise safety statistics. This will highlight the importance of budget for preventive efforts.

10. MEASUREMENTS OF SAFETY PERFORMANCE

10.1 Terminology:

IS:3786 defines as under :

Accident An unintended occurrence arising out of and in the course of employment of a person resulting in an injury.

Death: Fatality resulting from an accident

Disability Injury (Lost Time Injury) : An injury causing disablement extending beyond the day of shift on which the accident occurred.

Non-disabling Injury: An injury which requires medical treatment only, without causing any disablement whether of temporary or permanent nature.

Reportable Disabling Injury (Reportable Lost Time Injury) : An injury causing death or disablement to an extent as prescribed by the relevant statute (viz. the Factories Act and the ESI Act).

Days of Disablement (Lost Time): In case of disablement of a temporary nature, the number of days on which the injured person was partially disabled as defined below. In case of death or disablement of a permanent nature whether it be partial or total disablement as defined below, man-days lost means the charges in days of earning capacity lost due to such permanent disability or death as specified in Appendix B. In other cases the day on which the injury occurred or the day the injured person returned to work are not to be included as man-days lost, but all intervening calendar days (including Sundays, days off, days of plant shut down etc.) are to be included. If after resumption of work, the person injured is again disabled for any period arising out of the injury which caused his earlier disablement, the period of such subsequent disablement is also to be included in the man-days lost.

Partial Disablement: This is of two types; (i) disablement of a temporary nature which reduces the earning capacity of an employed person in any employment in which he was engaged at the time of the accident resulting in the disablement and (ii) disablement of a permanent nature which reduces his earning capacity in every employment which he was capable of undertaking at the time.

Total Disablement: Disablement, whether of a temporary or permanent nature, which incapacitates a workman for all work which he was capable of performing at the time of the accident resulting in such disablement, provided that permanent total disablement shall be deemed to result from every type of injury specified in Part A of Appendix A or from any combination of injuries specified in Part B of Appendix A where the aggregate percentage of the loss of earning capacity, as specified in that part against those injuries, amounts to one hundred percent.

Man-hours Worked: The total number of employee-hours worked by all employees working in the industrial premises. It includes managerial, supervisory, professional, technical, clerical and other workers including contractors' labour.

Man-hours worked shall be calculated from the pay roll or time clock record including overtime. When this is not feasible, the same shall be estimated by multiplying the total man-days worked for the period covered by the number of hours worked per day. The total number of man-days for a period is die sum of the number of persons at work on each day of the period. If the daily hours vary from department to department, separate estimates shall be made for each department and the result added together. When actual man-hours are not used, the basis on which the estimates are made shall be indicated.

Scheduled or Time Charge: For charges or equivalent man-days lost for death or total disablement see Part-A and for partial disablement see Part-B of Appendix-A of IS: 3786.

For death or total (100%) disablement, equivalent man-days lost are specified as 6000.

The Workmen's Compensation Act, 1923 also defines following terms:

Partial disablement of temporary nature or permanent nature, Total disablement (temporary or permanent), Wages and Workmen.

Section 4 and Schedule I & IV are important for calculating the amount of compensation. A concept of relevant (age) factor was added with effect from 1-7-1984. Section 4 was amended with effect from 15-9-1995 raising the limits of compensation.

The Employees State Insurance Act should also be referred where it is applicable. It also contains the similar terms and schedules.

See Part 7 of Chapter-29 and Part 6 of Chapter - 4 for further information.

10.2 Safety Performance Rates :

There are many types of safety performance rate as under:

10.2.1 Frequency Rate:

A question 'How often do injuries occur?' is replied by the frequency rate which is defined as the disabling (lost time) injuries per 106 man-hours worked.

$$F_1 = \frac{\text{No. of lost time injury} \times 10^6}{\text{Manhours worked}}$$

$$F_R = \frac{\text{No. of lost time injury} \times 10^6}{\text{Manhours worked}}$$

If the injury does not cause loss of time in the period in which it occurs but in a subsequent period the injury should be included in the frequency rate of the period in which the loss of time begins.

If an injury causes intermittent loss of time, it should only be included in the frequency rate once that is, when the first loss of time occurs.

Since frequency rate F, is based on the lost time injuries reportable to the statutory authorities, it ma) be used for official purposes only. In all other cases frequency rate F, should be used for comparison purposes.

In some country, the frequency coefficient (F) h determined by

$$F = \frac{\text{No. of injuries for a given period} \times 1000}{\text{Total Man – hours of exposure}}$$

10.2.2 Fatal Accident Frequency Rate(FAFR):

It indicates fatalities per 108 man-hours worked. It is the number of deaths from industrial injuries expected in a group of IOQO people during their working lives (1000 x 40 years x 52 weeks x 48 hours = 1000 x 40 x50x 50 = 10^8)

FAFR of chemical Industry			FAFR in UK Of		
France	-	8.5	Chemical Ind.	-	4
West Germany	-	5	Steel Ind.	-	8
UK	-	4	Coal Mining	-	40
USA	-	5	Air Crew	-	250
FAFR for non-industrial activities					
Staying at home	-	3			
Travelling by bus	-	3			
Travelling by car	-	57			
Traveling by air	-	240			
Motor cycling	-	660			
Rock climbing	-	4000			

10.3 Percentage Reduction in Frequency rate :

$$PRFR = \frac{\text{Frequency rate now} \times 100}{\text{Frequency rate past}}$$

This is used to decide awards. Average PRFR for two consecutive years is considered.

10.2.4 Weighted Frequency Rate:

While giving National Safety Award, this rate : considered and given bv -

$$WFR = \frac{(\text{No. of fatal accidents} \times 10) \times 10^6}{\text{Total man – hours worked}}$$

$$+ \frac{(\text{No. of permanent total dis – abilities} \times 10) \times 10^6}{\text{Total man – hours worked}}$$

$$+ \frac{(\text{No. of Nonfatal Accidents}) \times 10^6}{\text{Total man – hours worked}}$$

Here each fatal accident and permanent total disability are equated with 10 non-fatal accidents.

10.2.5. Safe T-Score :

It is given by

SafeT-Score =

$$\frac{\text{Frequency rate now – Frequency rate past}}{\sqrt{\dfrac{\text{Frequency rate past} \times 10^6}{\text{Manhours worked now.}}}}$$

Positive (+) STS indicates a worsening record while negative (-) STS indicates an improving record over the past.

If STS is **It indicates**

Between +2 & -2	Change is not significant. There may be random fluctuation only.
More than +2	Record is worsening than it was in the past. Something wrong has happened.
Less than – 2	Record is improving than it was in the past. Something better has happened.

Thus Safe-T-Score is useful to compare our safety record with the past and to control it if it is found worsening.

10.2.6. Incidence Rate:

General incidence rate is the ratio of the number of injuries to the number of employees during the period under review. It is expressed as the number of accidents or injuries, per 1000 persons employed.

$$I_L = \frac{\text{No. of lost –time accidents or injuries x 1000}}{\text{Average No. of persons employed}}$$

$$I_R = \frac{\text{No. of reportable lost time accidents or injuries x 1000}}{\text{Average No. of persons employed}}$$

10.2.7 Severity Rate:

A question 'How serious are the injuries? is replied by the severity rate which is defined as the number of days of lost time per 106 man-hours worked.

$$S_L = \frac{\text{Mandays lost due to lost time injury x } 10^6}{\text{Manhours worked.}}$$

$$S_R = \frac{\text{Mandays lost due to reportable lost time injury x } 10^6}{\text{Manhours worked.}}$$

The severity coefficient (S) is determined by

$$S = \frac{\text{Mandays lost in all accidents for a given period}}{\text{No. of injuries for a given period}}$$

Since severity rate S_R is based on the lost time injuries reportable to the statutory authorities, it should be used for official purposes only. In all other cases severity rate S_L should be used for comparison purposes.

Here man-days lost due to temporary total disability and man-days lost according to schedule of charges for death and permanent disabilities are as given in Appendix A (15:3786-1983). In case of multiple injury, the sum of schedule charges shall not be taken to exceed 6000 man-days. In Appendix A, equivalent man-days for death and other total disablement are 6000, and they are gradually decreased with decrease in percentage of loss of earning capacity against named partial disablement.

10.2.8 Mean Duration Rate:

It is an average number of days lost per accident

MDR = $\underline{\text{Total number of mandays lost}}$

$$= \frac{\text{Total number of accidents}}{}$$

$$= \frac{\text{Severity Rate}}{\text{Frequency Rate}}$$

It is also called average days charged or average severity per injury and given by:

$$\text{Average days charged} = \frac{\text{Severity Rate}}{\text{Frequency Rate}}$$

$$\text{Mandays lost per accident} = \frac{\text{Total days lost or charged}}{\text{Total no. of disabling injuries}}$$

10.2.9 Duration Rate :

It is an average number of man-hours worked per accident.

$$DR = \frac{\text{Number of manhours worked}}{\text{Total number of accidents}}$$

10.2.10 Disabling Injury Index:

$$DII = \frac{\text{Frequency Rate x Severity Rate}}{1000}$$

Disabling Index is also given as :

DII = Frequency Rate + 10% of Severity Rate.

This index can be used to compare plant to plant.

10.2.11 Frequency Severity Index or Indicator:

$$FSI = \frac{\text{Frequency rate x Severity rate}}{1000}$$

This is the square root of Disabling Injury Index. It gives combined effect of frequency and severity rate. This index can be used to compare-plant to plant. This can be used to indicate degree of improvement.

10.2.12 Motor Vehicle Accident Rate:

$$MVAR = \frac{\text{Number of accidents x } 10^6}{\text{Miles of operating exposure}}$$

10.2.13 The Cost Factor:

It is the total compensation and medical cost incurred per 1000 workers of exposure.

$$\text{Cost Factor} = \frac{\text{Cost incurred x 1000}}{\text{Total man-hours worked}}$$

Here cost incurred includes the actual compensation and medical costs paid for cases which occurred in a specified period plus an estimate of what is still to be paid for those cases. The 'estimated cost incurred' is an estimate of cost incurred based on averages.

'Cost of property damage' is a measure of damage to property of others caused by company (our) operations.

10.2.14 Cost Severity Rate:

$$\text{Cost Severity Rate} = \frac{\text{Total cost of accidents} \times 10^6}{\text{Total Production Man-hours}}$$

10.2.15 Money Loss Rate:

$$\text{MLR} = \frac{\text{Loss expenditure} \times 10^6}{\text{Manhours worked or Miles of Operating Exposure}}$$

$$\text{Loss Ratio} = \frac{\text{Direct money loss paid out in claims}}{\text{Premium paid to Insurance Company}}$$

10.2.16 Safety activity rate:

It is determined by the following formula :

$$\text{SAR} = \frac{\text{Safety Activity} \times 5 \times 10^6}{\text{Man-hours worked} \times \text{Average No. of employees}}$$

Here 'Safety activity' is the sum (during the unit period) of safety recommendations made, unsafe practices reported, unsafe conditions reported and the number of safety meetings held. Thus a safety activity rate curve can be plotted for any period - a week, month, year etc. and the safety performance can be compared.

10.2.17 Risk of Accident:

It is a product of probability (frequency) of the occurrence of an accidental event of a given kind and of its severity (consequence).

Accident Risk = Total Loss of all accident occurrences

$RAC = (FK \times SC)_A$

Where

FK = Frequency FK i.e. number of accidents A of a

given kind in period of time = A / T

SC = Severity SC i.e. magnitude of consequence C from

accident A of a given kind = C / A

10.2.18 The Rate of Labour Turnover:

It is expressed as T = S/F

Where

T = Rate of Labour Turnover

S = No. of Separations
F = Average labour force for a given period of time.

By multiplying the fraction by 100, the percentage turnover is obtained.

If R = No. of Replacements and U = Unavoidable Separations, the rate is also given as

T = R /F and T = R – U / F

Statistical Period:

Rates for any period, that is month, quarter or year shall include injuries which occurred during the period, together with any injuries which occurred in the previous 12 months and which have not already been included in earlier calculations.

Any injury which occurred in a previous period and which did not cause lost time at the time of occurrence, but caused lost time in the current period, shall be included as a lost time injury in the current period.

10.3 Significance and Drawbacks of Injury Rates:

10.3.1 Significance of Injury Rates :

1. The injury rates are useful to -

   (a) Measure the frequency and seriousness of accidents of a given department, branch or a factory.
   (b) Determine from month to month or year to year whether the condition is getting better or worse.
   (c) Compare the experience of one operating unit with one or more other similar units and
   (d) Serve as a basis for an accident-prevention contest between two or more operating units.

2. A serious accident has a considerable effect on the accident severity rate (due to increased mandays lost) but it does not greatly affect the accident frequency rate.

3. The frequency and severity rates give valuable information on the-safety situation of an industry or its departments within the industry. They are useful in planning the immediate safety measures to control accidents in the industry.

4. Injury rates can be computed for a week, a month, a year or for any period of time by using the same formula. Thus they .form a base of accident statistics for a particular period. The rates are useful in comparing safety records for the same period of two or more plants, even though they are dissimilar in size.

5. Frequency rate can be used to compare present safety performance with the past and the good or bad performance of our own or of others. A high frequency rate indicates need to reduce accidents, but it is unable to give any hint as to what action.

6. Reduction in severity rate indicates a reduction in deaths and other serious injuries. Increase in severity rate, even though the frequency rate is decreased, indicates a definite need for effective Measures to eliminate hazards. Decrease in frequency rate may not necessarily bring decrease in severity rate. Circumstances causing them may be different.

7. Severity is a matter of good or bad luck but it is connected with frequency. Out of ten accidents, there may not be any serious accident, but out of hundred, there may be some serious accidents. Therefore it is said that take care of the frequency rate, then the severity rate will take care of itself. But this is not completely true. Even one or few accidents can result in fatality or seriousness. Therefore, safety measures are more important.

8. Frequency rate can become a basis for comparing two or more units, in a safety contest. Severity rate cannot become a good basis of comparison except when the severity only is to be compared in all units.

9. Where small, minor or first-aid cases are excluded, to keep the safety record good, it is always necessary to give first-aid or necessary treatment to all such cases and to remove the hazards.

   Prompt first-aid and redressing action to injured workers decreases the man-days lost which in turn, decreases the severity rates.

10. Safety engineers/officers can use the injury rates
    (a) To compare their units with the average for the industry.
    (b) Their periodical safety improvement or deterioration.
    (c) To find less hazardous operations.
    (d) To check how well their departments are doing (an increase in rates indicates lack of supervisory control) and
    (e) To determine which department had the best performance etc.

10.3.2 Drawbacks of Injury Rates :

1. No rate is capable of giving complete picture of safety performance. The frequency rate indicates a number of accidents per man-hours worked only. Type, cause, severity, agency or factors of accidents are not represented. The severity rate indicate a ratio of total man-days lost to total man-hours worked only. Type, cause, frequency, agency or factors of accidents are not represented Thus, die injury rates are the partial indicators of injury cases only.

2. Many accidents and property damage or time losses not causing any man-days lost are not properly indicated by frequency or severity rates.

3. Comparing two plants / factories based on their frequency or severity rates is not a good practice. It does not give correct picture as the types of hazard, working conditions/ actions, number and type of manual handling or exposure, attitude of workers, attitude of management etc. differ between them and these factors have definite effects on the frequency and the severity rates.

4. Denominator of both the rates (FR & SR) is 'man-hours worked'. Mostly these figures are selected from 'Attendance Register and there is a difference between 'Attendance in Register' and actually working under hazard. Many supervisors, officers and workers sit in offices or cabins or have idle hours. Even then "such hours' are included in 'man-hours worked'. Thus these rates do not give the absolute correct safety picture.

5. Severity rate indicates only 'absence' due to an accident. It does not represent actual severity of pain and suffering of a worker. Equal severity rates of two factories indicate 'the same status of safety~ therein, while it is a fact that there may be wide difference in types of injuries, their seriousness, pain and suffering. The same 'man-days lost’ are possible by ten normal accidents or by one serious accident and the result (severity rate) will be the same.

6. In frequency, severity and other rates, multiplication by 106 gives high figures. Labour Bureau, Shimla, uses W. See Table 5.2 and 5.9.

These are some drawbacks of injury rates.

10.4 Worked Examples :

1. Calculate different injury rates for. a factory employing average 50 workers for the year during which 100 lost-time (disabling) injuries (accidents) took place and totally 500 man-days lost. The workers worked 48 hours a week and S2 weeks in the year. If total cost of the above 100 accidents is Rs. 70,500 calculate the cost severity rate.

$$\text{Frequency rate} = \frac{\text{Injury} \times 10^6}{\text{Man-hours worked}}$$

$$= \frac{100 \times 10^6}{50 \times 48 \times 52} = 801.28$$

$$\text{Severity rate} = \frac{\text{Mandays lost} \times 10^6}{\text{Man-hours worked}}$$

$$= \frac{500 \times 10^6}{50 \times 48 \times 52} = 4006.41$$

$$\text{Incidence rate} = \frac{\text{Injuries} \times 1000 \quad 0}{\text{Average workers employed}}$$

$$= \frac{100 \times 1000}{50} = 2000$$

$$\text{Disabling Index} = \frac{\text{Frequency rate} \times \text{Severity rate}}{1000}$$

$$= \frac{801.28 \times 4006.41}{1000} = 3210.256$$

$$\text{Average days charged} = \frac{\text{Sev. Rate}}{\text{Freq. rate}} = \frac{4006.51}{801.28} = 5$$

$$\text{Or} = \frac{\text{Mandays lost}}{\text{Freq. rate}} = \frac{500}{100} = 5$$

$$\text{Frequency Coefficient} = \frac{\text{Injuries} \times 1000}{\text{Man- hours worked}}$$

$$\text{Severity Coefficient} = \frac{\text{Mandays lost}}{\text{Injuries}} = \frac{500}{100} = 5$$

$$\text{Cost Severity rate} = \frac{\text{Total cost of accidentx } 10^6}{\text{Man-hours worked}}$$

$$= \frac{70500 \times 10^6}{50 \times 48 \times 52} = 564903.84$$

2. If in the factory of Example (1) above, there were 150 safety recommendations, 390 unsafe practices reported, 50 unsafe conditions reported and 10 safety meetings and programmes arranged during the year, calculate the safety activity rate.

$$\text{Safety Activity Rate} = \frac{\text{Total Safe Activity} \times 5 \times 10^6}{\text{Man – hours worked} \times \text{Av. Workers employed}}$$

$$= \frac{(150 + 390 + 50 + 10) \times 5 \times 10^6}{50 \times 48 \times 52 \times 50} = 480.76$$

3. In a factory the average daily rate of employment per shift is 1500.' There are 3 shifts of 8 hours. In a year, the factory works for 300 days. If the total reportable accidents in the year was 80 and man-days lost were 200, find the frequency and severity rates of accidents, and the Frequency Severity Indicator.

$$F = \frac{80 \times 10^6}{1500 \times 8 \times 3 \times 300} = 7.40$$

$$S = \frac{2000 \times 10^6}{1500 \times 8 \times 3 \times 300} = 18.51$$

$$FSI = \frac{F \times S}{1000} = \frac{7.40 \times 18.51}{1000} = 0.1369$$

4. Firm A has 60 workers working 48 hours a week and 20 accidents (lost time) resulting in 120 man-days lost. Firm B has 80 workers working 48 hours a week and 30 accidents resulting in 150 man-days lost. Which firm has the better safety performance during the same six months?

Six months = 52 / 2 = 26 weeks

$$FA = \frac{\text{Injuries} \times 10^6}{\text{Manhours worked}} = \frac{20 \times 10^6}{60 \times 48 \times 26} = 0267.09$$

$$FB = \frac{\text{Injuries} \times 10^6}{\text{Manhours worked}} = \frac{30 \times 10^6}{80 \times 48 \times 26} = 0300.48$$

$$S_A = \frac{\text{Mandays lost} \times 10^6}{\text{Manhours worked}} = \frac{30 \times 10^6}{80 \times 48 \times 26} = 0300.48$$

$$S_A = \frac{\text{Mandays lost} \times 10^6}{\text{Manhours worked}} = \frac{150 \times 10^6}{80 \times 48 \times 26} = 1502.40$$

Comparing frequency rates, firm A has less rate, therefore better safety performance from frequency point of view. Comparing severity rates, firm B has less rate, therefore better safety performance from severity point of view.

5. Given below are accident statistics of Factories A & B :

Factory	Manhours worked	Non fatal Accidents	Fatal Accidents	Man days Loss
A Regular workers Contract workers	 1200000 250000	 10 2	 - -	 400 100
B Regular workers contact workers	 3000000 500000	 24 8	 - 1	 1000 120

(a) Calculate frequency rate separately for regular workers and contract workers including weighted frequency rate.

(b) Calculate severity rate separately for regular workers and contract workers including days charged for the fatal accident.

(c) Comment on the safety performance between

For Factory A

FRW = $\frac{10 \times 10^6}{12 \times 10^5} = \frac{100}{12} = 8.33$ (for regular workers)

FCW = $\frac{2 \times 10^6}{25 \times 10^5} = \frac{200}{25} = 8.00$ (for contract workers)

Weighted Freq. Rate $= \frac{(10+2) \times 10^6}{1200000 + 250000} = 8.27$

SRW = $\frac{400 \times 10^6}{12 \times 10^5} = \frac{4000}{12} = 333.3$

SCW= $\frac{100 \times 10^6}{25 \times 10^4} = \frac{1000}{25} = 400$

For Factory B

FRW = $\frac{24 \times 10^6}{3 \times 10^6} = \frac{24}{3} = 8$

FCW = $\frac{(8+1) \times 10^6}{5 \times 10^6} = \frac{90}{5} = 18$

Weighted Freq. Rate $= \frac{(24+8+1) \times 10^6}{3000000 + 500000} = 9.42$

SRW = $\frac{1000 \times 10^6}{3 \times 10^6} = \frac{1000}{3} = 333.3$

SCW = $\frac{(6000 + 120) \times 10^6}{5 \times 10^5} = \frac{61200}{5} = 12240$

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Weighted Freq. Rate

(24 + 8 +1) x l(r

SRW

3000000+ 500000

1000x10" 1000 _..

3x10"   3 (6000+120) x 6 61200

considering 6000 man-days lost for I fatal accident (IS:3786-1983).

Comment : In case of regular workers, freq. rate of factory B is less than that of factory A and therefore good performance. In case of contract workers, the situation is reversed In case of regular workers, severity rate of both the factories is equal and therefore equal performance. In case of contract workers, the factory B has higher severity rate (which increased due to a fatal accident) and therefore comparatively poor performance. Comparing weighted frequency rates, total work performance of regular and contract workers of factory A is good.

6. For a medium size engineering factory, frequency rate ‘f’ and severity rate 's' for four consecutive years are given below in Table 1. Calculate the man-days lost per accident 'D' and Frequency-Severity Indicator 'FSI'. Arrange in descending order of safety performance, the four years for each index and for the overall performance rating. Use Table I and II for the final answer by filling the blanks.

Table 1				
Index	Year			
	1	2	3	4
F	17	15	10	9
S	174	175	83	108
D				
FSI				

Table 2				
Index	Year			
	4	3	2	1
F				
S				
D				
FSI				
Overall				

In Table - I, man-days lost per accident

$D_1 = \underline{S} \quad = \quad \underline{174} \quad = \quad 10.23$

$$\begin{matrix} & F & & 17 & & \end{matrix}$$

$$D_2 = \frac{S}{F} = \frac{175}{15} = 11.66$$

$$D_3 = \frac{S}{F} = \frac{83}{10} = 8.3$$

$$D_4 = \frac{S}{F} = \frac{108}{9} = 12.00$$

Frequency - Severity Indicator :

$$FSI_1 = \frac{F \times S}{1000} = \frac{17x174}{1000} = 1.719$$

$$FSI_2 = \frac{F \times S}{1000} = \frac{15x175}{1000} = 1.62$$

$$FSI_3 = \frac{F \times S}{1000} = \frac{10x83}{1000} = 0.911$$

$$FSI_4 = \frac{F \times S}{1000} = \frac{9x108}{1000} = 0.98$$

Arranging in descending order of Safety performance for each index.

For F	Because	Year F	=	4^{th}, 9	3^{rd}, 10	2^{nd} 15	& &	1^{st} 17
For S	Because	Year S	=	3^{rd} 83	4^{th} 108	1^{st} 174	& &	2^{nd} 175
For D	Because	Year D	=	8.3 3^{rd}	10.23 4^{th}	11.66 2^{nd}	& &	12.00 1^{st}
For FSI	Because	Year FSI	=	0.911 3^{rd}	0.98 4^{th}	1.62 2^{nd}	& &	1.719 1^{st}
For Overall	Because		S,D,FSI 3 times less	S, FSI 2 times less	F, D, FSI, 3 times less	F, FSI 2 times less and last		

The final answer is, therefore, given below by filing the blanks in both the Tables:

Table I				
Index	Year			
	1	2	3	4
F	17	15	10	9
S	174	175	83	108
D	10.23	11.66	8.3	12
FSI	1.719	1.62	0.911	0.98

Table II

Index	Year			
	1	2	3	4
F	4th	3rd	1st	2nd
S	3rd	4th	1st	2nd
D	3rd	1st	2nd	4th
FSI	3rd	4th	2nd	1st
Overall	Good	Satisfactory	Poor	Bad

7. In a factory in 1996, 80 accidents occurred when 200 workers worked for the whole year. In 1997. 120 accidents occurred with the same employment. Calculate the Safe-T-Score for the year 1997 and comment on the performance.

$$FR_{1996} = \frac{80 \times 10^6}{200 \times 48 \times 52} = \frac{80000000}{499200} = 160.25$$

$$FR_{1997} = \frac{120 \times 10^6}{200 \times 48 \times 52} = \frac{120000000}{499200} = 240.38$$

$$STS_{1997} = \frac{FR_{1997} - FR_{1996}}{\sqrt{\frac{FR_{1996} \times 10^6}{Manhours_{1997}}}}$$

$$= \frac{240.38 - 160.25}{\sqrt{\frac{160.25 \times 10^6}{499200}}} = \frac{80.13}{\sqrt{321.14}} = \frac{80.13}{17.92} = 4.47$$

As the STS 4.47 is more than +2, it indicates that the safety performance is worsened.

8. In a factory during 1992, 15 accidents took place when 70 workers were employed for six months. In the same factory when it worked for the whole year in 1996 with 90 workers, total 25 accidents took place. Calculate the Safe-T-Score for 1996 and comment on the performance.

Six months = 26 weeks.

$$FR_{1992} = \frac{15 \times 10^6}{70 \times 48 \times 26} = \frac{15000000}{87360} = 171.70$$

$$FR_{1996} = \frac{25 \times 10^6}{90 \times 48 \times 52} = \frac{25000000}{224640} = 111.28$$

$$STS_{1996} = \frac{FR_{1996} - FR_{1992}}{\sqrt{\frac{FR_{1992} \times 10^6}{Manhours_{1996}}}}$$

$$= \frac{111.28 - 171.70}{\sqrt{\frac{171.70 \times 10^6}{224640}}} = \frac{-60.41}{\sqrt{764.33}} = \frac{-60.41}{27.64} = -2.18$$

As the Safety-T-Score for 1996 is -2.18 i.e. less than -2, it indicates that the safety performance i improved.

9. Safety performance of two factories is as under

	Factor A	Factory B
Workers	750	1580
Accidents in pervious year	140	225
Accidents in current year	120	210
Working days in previous year	310	290
Working days in current year	160	240

Compare the Safe-T-Score of both the factories and comment on their Performance –

$$FR_P = \frac{140 \times 10^6}{750 \times 310 \times 8} = \frac{140000000}{1860000} = 75.26 \qquad FR_P = \frac{225 \times 10^6}{1580 \times 290 \times 8} = \frac{225000000}{3665600} = 61.38$$

$$FR_C = \frac{120 \times 10^6}{750 \times 160 \times 8} = \frac{120000000}{960000} = 125 \qquad FR_C = \frac{210 \times 10^6}{1580 \times 240 \times 8} = \frac{210000000}{3033600} = 69.22$$

$$STS_A = \frac{125 - 75.26}{\sqrt{\frac{75.26 \times 10^6}{960000}}} \qquad STS_B = \frac{69.22 - 61.38}{\sqrt{\frac{61.38 \times 10^6}{3033600}}}$$

$$= \frac{49.74}{\sqrt{78}} = \frac{49.74}{8.83} = 5.63 \qquad = \frac{7.84}{\sqrt{20.25}} = \frac{7.84}{4.5} = 1.74$$

Comment: Decrease in accidents and decrease in working days in both the factories do not give clear picture for comparison of factory A & B. Comparison of rise in frequency rates in both the factories indicates that there was more rise in FR of factory A than that of factory B and therefore the performance of factory A was comparatively worsened.

Safe-T-Score of factory A is 'more positive than that of factory B and this clearly indicates that the safety performance of factory A is poorer than that of factory B.

10. In a factory average labour force employed i 620. If the workers to be separated are 40 calculate the rate of labour turnover. If instead of separations, 36 are replaced with unavoidable separations, calculate the rate :

Rate of labour turnover

$$T = \frac{S}{F} = \frac{40}{620} = 0.064 \times 100 = 6.4\%$$

Considering replacement

$$T = \frac{R}{} = \frac{36}{} = 0.058$$

$$F \qquad 620$$

Considering unavoidable separation

$$T = \frac{R-U}{F} = \frac{36-4}{620} = 0.051$$

For examples of compensation due to industrial injuries and costs of accident, see Part 3 & 4 of this Chapter.

10.5 Benchmarking for Safety Performance

'Benchmarking means to find and follow the **"best practices'** to produce or get the best result in terms of performance, profit, productivity etc.

This process can be applied for safety performance also. The top management or the Safety Department can constitute a team of experienced supervisors or engineers to notice following things:

1. What are the defects in present practices to work on machines, vessels, equipment etc. and doing some hazardous jobs.

2. To think and search for the 'best practices" to remove above defects and to follow these best practices to reduce accidents and to improve the safety performance rates.

3. Such search of 'best practices' can be derived by interviews and discussing with own people or from outside work places where such best practices are followed and good results are achieved.

4. Then such decided 'best practices' should be implemented at desired places and when they give desired results, they .should be 'benchmarked' as a target for improvement.

5. Similarly from other observations and past record of accidents, other areas, work methods, plant, machinery and technology should be identified which need improvement for better performance. Then steps 2 to 4 should be repeated to search and follow the best practices for these areas also.

'Benchmarking' when followed, highlights strengths and weaknesses and suggests the ways and means for improvement.

"Matrix' can also be decided to benchmark certain areas of work like-

1. Reduction of accidents due to particular material, process or product.

2. Reduction in batch time or in manual exposure time.

3. Getting less rejects.

4. Getting more yield per unit of input.

5. Improving safety performance rate and winning 'awards' based on that.

Best safety standards should be listed and followed for best practices. The benchmarked standards should be equal to or lower than the statutory standards. The benchmarking process should be well documented for the use of others.

Many companies in the world have followed 'benchmarking' practices and improved themselves.

One example of project benchmarks decided and followed by one company is as under:

1. Reduction (to be achieved) in noise level by 5 dBA at identified areas.

2. Reduction (to be achieved) in average noise level exposure to 80 dB in 8 hrs in identified areas.

3. Reduction in dust exposure in Catalyst bagging area up to 8 "g/m" as against allowable of 10 mg/m^3.

4. Reduction in respirable dust exposure in RCH unloading area up to 2 mg/m^3 as against allowable of 3 mg/m"

5. Awareness of the health hazards of heat stress and reducing exposure.

Similarly any company can decide target areas and the benchmarked standards for them and make sincere efforts to achieve these standards.

11. BUDGETING FOR SAFETY

A budget is a plan for any period to show proposed or future anticipated and correctly estimated figures for money, material, time etc. to start or continue work for desired goals.

Mostly annual budgets are made for financial requirement. It may be by an individual, industry, office, State or Nation etc.

Discussion in foregoing Parts 3 to 9 reveals many elements of accident or safety costs and suggests need of budgeting for safety. It is important to know such costs for planning and budgeting for safety in industry.

11.1 Purpose and Procedure of Safety Budgeting :

It is obvious that every management should think about the effect of safety activities on its profits. Though it is true that the management likes to support safety programmes on humanitarian grounds, 'money and profit' is still a driving force for them as stated by R.B. Blake, a senior safety official of US Department of Labour, as early as in 1944. The main driving force behind the industrial safety movement should be the fact that accidents are expensive and substantial savings can be had by preventing them.

Money is an important measure to evaluate company performance and if it can be shown .that there is a financial return for money allocated to Safety Department, the top executive will certainly support it. Financial or economic benefits or costs savings by Safety Department should be properly exhibited to the top management in the form of budget for safety. .

Where there are high risks or serious hazards, the cost of the safety provisions can be far less than the cost of consequences. The world disasters have proved this. Estimates of such preventive activities are an important part of safety budget.

While discussing budgetary requirement, it should be emphasised that safety is a legal requirement as well as moral, humanitarian and social duty also and ultimately it results in productivity (uninterrupted production or less shutdowns), in reducing accident costs and maintaining workers' interest, morale and cooperation. . See Part-4 of Chapter-4 also.

Procedure for preparing and presenting safety budget may differ between factories and depend on size and status of them. In a small factory where there is no Safety Officer or Safety Department, a common person for all budgetary aspects should consider all safety items under a separate head of 'Safety or SHE provisions'

In a big or well organised factory, officers of safety or SHE department should sit together and design and fill a budget proposal form and after due discussion it should be finalized and sent to the top management for approval. Approved budget should be properly and timely utilized.

Budget procedure (process) has four steps.

1. Planning and projection.
2. Use of the money allotted.
3. Feedback or control by comparing real expenditure with the budgeted amount, and
4. Corrective action to re-adjust the budget for the rest of the period.

Essentials of good budget are - Planning, controlling and coordinating human activities for profit and productivity, link between past, present and future, clarity, certainty, flexibility etc.

Money to be invested (future estimate for budget purposes) in purchasing, fitting, maintaining and using safety equipment, instruments and devices can be considered as 'safety costs' if it is not considered as direct production or maintenance costs.

Money necessary for safety education, training and programmes is the direct cost for safety if it is not considered as general administrative or general education and training costs for employees.

Salaries to the safety personnel (own employees) should be included in general wage-bill of all employees but the payments (provision) to safety consultants, professionals, competent persons or experts (outsiders) can be considered as direct safety costs.

For a new or running plant, all costs for HAZOP, safety audit, risk assessment, design cost and costs for all built-in safety devices must be considered well in advance.

Estimates of direct and indirect costs of some predictable accidents can also give the figures for safety budget

Estimates for catastrophes, fires, emergencies, major hazards and safety analysis, assessment, audit, public liability insurance etc. should also be considered.

Normally following items are considered for safety budget:

1. Respiratory Personal Protective Equipment.
2. Non-respiratory Personal Protective Equipment.
3. Anemometer.
4. Gas tight suits.
5. Acid/Alkali/Chemical Splash Contamination Suits.
6. Fire Proximity Suits.
7. Flame retardant suits / overall.
8. Water Jell Blankets.

9. Safety Hand-lamps with charger.
10. Safety Torch (explosion proof).
11. Flame arresters for vehicles.
12. Safety showers.
13. First Aid Kit for ____ persons.
14. Levelling/ Printing Machine.
15. Safety Display Boards with Stand.
16. Display cabinet for safety items.
17. Air movers.
18. Roof top safety ladders (crowling boards).
19. Gas detection tubes.
20. Road closed barriers with board and stand.
21. Barrier cream.
22. Wind sock set / cloth.
23. Chlorine leakage control kit.
24. Ammonia leakage control kit.
25. Multi-gas detectors (e.g. CO, H2S, HC, Cl, NH,,).
26. Oxygen meters.
27. Hydrogen detectors.
28. Safety stickers.
29. Boiler / Inspection overalls.
30. Construction or up-gradation of Safety Centre for Exhibition and Training.
31. Painting / Re-painting cost for safety boards, banners, slogans etc.
32. Travelling charges to attend Govt Offices for safety or statutory work.
33. Fees, travelling and other expenses to attend safety seminars, programmes etc.
34. Vehicle charges for Safety Department.
35. Printing charges for safety information booklets, emergency instruction booklets, tremcards etc.
36. Stationary items, Xerox, and other printing charges.
37. Mock drill of On-site /0ff-site Emergency Plans.
38. Celebration of National Safety Day and other safety award programmes.
39. Computer software for gas dispersion models and consequence analysis etc.
40. New safety products like non-asbestos blanket, splash guard, flange guard etc.

The top management must make adequate provision for safety budget every year based on above considerations.

11.2. Consideration of Safety Performance Rates

Various types of safety performance rates are stated in foregoing parts 10.2 and 10.3.

Safety Officer or Department should calculate such different rates applicable to the factory. Cost of annual average man-hours or man-days lost and annual medical and other expenses for accidents happened during previous year should be considered and projected as budgetary estimate for the next year.

Expenditure (estimate) necessary for preventive measures to reduce such accidents (rates) should also be considered and included in the budget.

Performance rates and expenditure in controlling them should be compared from year to year to monitor decrease in such expenditure.

12. STATISTICAL TABLES AND THEIR CONCLUSION

A few selected tables are given here to study the industrial safety statistics of India and the State of Gujarat.

The most authentic sources such as Labour Bureau, Shimla, the Office of the Chief Inspector .of Factories, Ahmedabad and the Loss Prevention Association of India are used and acknowledged with gratitude. However, due to under-reporting, late reporting or no-reporting, the data is inadequate. Nevertheless it is the only tool to draw some inference.

Table 5.1 Number of Working Factories and Average Daily Employment

Sr. No.	State / UTs	Year	No. of working Factories	Average Daily Employment ('000)
1	Andhra Pradesh	1993	23986	655
2	Assam	1994	1652	106
3	Bihar	1989	42580	483
4	Goa	1994	286	21
5	Gujarat	1993	15062	796
6	Haryana	1993	5355	258
7	Himachal Pradesh	1993	1349	56
8	Jammu & Kashmir	1986	651	27
9	Karnataka	1994	8724	689
10	Kerala	1988	12038	283
11	Madhya Pradesh	1994	10189	558
12	Maharashtra	1994	26072	1283
13	Manipur	1992	459	5
14	Meghalaya	1994	53	2
15	Orissa	1994	1853	140
16	Punjab	1993	12340	405
17	Rajasthan	1994	13406	330
18	Tamil Nadu	1993	17471	991
19	Tripura	1994	1136	32
20	Uttar Pradesh	1992	13090	853
21	West Bengal	1990	8981	906
22	A & N Islands	1991	45	5
23	Chandigarh	1991	456	16
24	D & N Haveli	1993	137	5
25	Delhi	1993	5498	259
26	Pondicherry	1994	1174	29

Source : Indian Labour Journal, December 1996.

Table 5.2 Number of Working Factories and Average Daily Employment

Year	Fatal Injuries			Nonfatal Injuries			Total Injuries		
	Number	IR	FR	Number	IR	FR	Number	IR	FR
1985	630	0.15	0.05	217328	51.74	17.97	217958	51.89	18.02
1986	784	0.15	0.05	253184	49.41	15.30	253968	49.56	15.35
1987	748	0.17	0.05	212302	47.42	14.23	213050	47.58	14.28
1988	748	0.17	0.06	177112	35.56	11.92	117860	35.73	11.98
1989	706	0.16	0.05	161331	34.05	10.88	162037	34.21	10.93
1990	663	0.21	0.04	127454	32.90	6.99	128117	33.11	7.03
1991	486	0.21	0.07	60113	25.99	8.24	60599	26.20	8.31

Source : Indian Labour Statistics 1991-93.

NB : In above figures information not received from many states is not included, e.g. figures for 1985 excludes 10 States and for 1991 excludes 11 states. Only reportable accidents under the Factories Act are considered. IR is per one thousand workers employed and FR per one lakh man- days worked.

Table 5.3 Number of working factories in India, Estimated Average Daily Employment, Reportable Injuries and their Incidence Rates (IR)

Year	Working Factories	Average Daily Employment (in '000)	Industrial Injuries		IR per thousands workers employed in factories submitting returns	
			Fatal	Total	Fatal	Total
1971	81078	5085	635	325180	0.15	75.67
1972	86297	5349	655	285914	0.15	63.63
1973	91055	5500	666	286010	0.15	62.58
1974	97065	5670	650	249110	0.14	53.77
1975	104374	5771	660	242352	0.14	50.86
1976	113216	6127	831	300319	0.17	61.54
1977	119715	6311	690	316273	0.14	63.95
1978	126241	6540	792	332195	0.15	68.62
1979	135173	6802	829	318380	0.16	62.19
1980	141317	7017	657	316532	0.14	66.92
1981	149285	7240	687	333572	0.16	76.73
1982	157598	7388	549	296027	0.13	69.10
1983	163040	7444	458	213160	0.13	55.63
1984	167541	7603	824	302726	0.10	36.72
1985	175316	7691	807	279126	0.23	58.70
1986	178749	7795	924	276416	0.14	49.31
1987	183586	7835	895	236596	0.14	41.54
1988	188136	8153	694	200258	0.15	41.68
1989	193258	8330	706	162037	0.16	35.11
1990	199826	8431	663	128117	0.21	33.11
1991	207980	8547	486	60599	0.21	26.20
1992	207156	8618	573	74195	0.20	26.54

Source : Hand Book of Labour Statistics, Labour Bureau, Shimla

Note : (P) = Provisional, Incomplete Data

Table 5.4 : Average Daily Employment, Reportable Accidents and Incidence Rates in Six States.

State	1993				1994			
	A	B		C	A	B		C
		A	B			A	B	
Gujarat	810000	184	14620	18.04	812848	194	15683	19.29
Madhya Pradesh	530448	69	9865	18.06	533309	70	8965	16.81
Maharashtra	979795	1324	27395	22.00	346087	147	23810	-
Orissa	143316	37	3064	22.00	140004	29	3112	22.00
Pondicherry	26647	3	1178	44.21	29135	3	1049	36.90
Tamil Nadu	927975	73	11407	11.72	1009526	-	9150	9.06

State	1995			
	A	B		C
		a	b	
Gujarat	822200	192	15232	18.53
Madhya Pradesh	545537	83	8244	15.11
Maharashtra	-	185	20769	-
Orissa	150579	42	3291	29.00
Pondicherry	33549	2	586	17.41
Tamil Nadu	1038526	-	6903	6.65

A. Average Daily Employment
B. No. of reportable Accidents
a. Fatal
b. Total
C. Incidence rate of total injuries per 1000 workers employed
* Calculated from the data supplied by the CIFs

Source : Information supplied by the CIF's.

Table 5.5 Industrial injuries in Factories and their Incidence Rate and Frequency Rate, 1992, by States.

States	Number		IR		FR	
	Fatal	Non Fatal	Fatal	Nonfatal	Fatal	Nonfatal
Andhra Pradesh	75	6256	0.18	14.71	0.02	1.75
Assam	18	446	0.27	6.62	0.10	2.59
Bihar	-	-	-	-	-	-
Goa	4	354	0.20	17.29	0.06	5.60
Gujarat	119	13753	0.26	29.79	0.09	9.90
Haryana	24	1411	0.18	10.58	0.06	3.41
Himachal Pradesh	-	-	-	-	-	-
Jammu & Kashmir	-	-	-	-	0.13	-
Karnataka	17	1210	0.16	11.52	0.04	3.92
Kerala	-	-	-	-	-	-
Madhya Pradesh	81	13461	0.42	69.96	-	20.87
Maharashtra	132	25138	0.13	25.01	0.08	8.12
Manipur	-	-	-	-	0.10	-
Meghalaya	-	12	-	5.33	0.12	1.63
Orissa	27	3763	0.25	35.02	-	10.75
Punjab	30	1976	0.26	17.16	-	6.31
Rajasthan	46	4984	0.38	41.00	-	12.65
Tamil Nadu	-	-	-	-	-	-

Tripura	-	4	-	0.73	-	0.27
Uttar Pradesh	-	-	-	-	-	-
West Bengal	-	-	-	-	-	-
A & N Islands	-	-	-	-	-	-
Chandigarh	-	-	-	-	-	-
D & N Haveli	-	-	-	-	-	-
Delhi	-	854	-	50.10	-	15.72
Pondicherry	573	73622	0.20	26.34	0.5	6.79

Source : Pocket Book of Labour Statistics 1995, Labour Bureau, Shimla.

NB: (1) Sum of the rates of Fatal and Non fatal injuries gives the rate of total injuries.
(2) The number of injuries (Fatal & Non-fatal) have been given on the basis of notices of accidents whereas the incidence rates has been worked out on the basis of injuries reported in the Annual Returns.
(3) IR is per 1000 workers and F is per one lakh Mondays worked.

Table 5.6 Industrial Injuries in Factories and their Incidence Rate and Frequency Rate by important Industries, 1992.

Industry	Number		IR		FR	
	Fatal	Non Fatal	Fatal	Nonfatal	Fatal	Nonfatal
All Textiles	67	33047	0.02	8.55	0.03	14.80
Wood and Wood products, Furniture and Fixture	10	317	0.27	8.69	0.08	2.45
Paper and Paper products, Printing & Publishing.	18	2052	0.15	17.39	0.05	5.18
Chemical and Chemical products	80	4061	0.28	14.27	0.09	4.45
Non-metallic Mineral products	46	4166	0.27	24.39	0.03	2.95
Basic Metal Industries	86	7557	0.39	34.61	0.12	10.29
Metal Products (except Machinery)	15	1748	0.14	15.96	0.04	5.06
Machinery and equipment (Other than Transport)	25	5730	0.07	16.00	0.02	5.22
Transport equipment	25	4716	0.17	31.85	0.06	11.27
Electricity, Gas and Steam.	24	841	0.42	14.80	0.12	4.31

Source : Pocket book of Labour Statistics, 1995

NB: (1) Sum of the rates of Fatal and Non fatal injuries gives the rate of total injuries.
(2) The number of injuries (Fatal & Non-fatal) have been given on the basis of notices of accidents whereas the incidence rates has been worked out on the basis of injuries reported in the Annual Returns.
(3) IR is per 1000 workers and F is per one lakh Mondays worked.

Table 5.7: Accidental Deaths in India by Causes during 1994 & 1995

Sr. No.	Causes of Accidental Deaths	Number of Accidental Deaths		Percentage share of each Cause	
		1994	1995	1994	1995
	(A) Natural Causes :				

1	Lightening	1615	1664	0.8	7.7
2	Heat Stroke	773	1677	0.4	7.76
3	Flood	797	6822	0.4	3.81
4	Landslide / Earthquake	584	502	0.3	2.32
5	Cold and Exposure	525	618	0.3	2.86
6	Cyclone	145	180	0.1	0.83
	Total (A)	**4439**	**21600**	**2.3**	**100**
	(B) Unnatural Causes :				
1	Firearm	2375	1052	1.2	0.52
2	Explosion	487	581	0.3	0.29
3	House Collapse	1190	1590	0.6	0.79
4	Total Road Accidents	51855	68351	27.2	34.02
	(i) M.V. Accident	[46393]	[68351]	[24.4]	[34.02]
	(ii) Other Road Accident	[5462]	-	[2.8]	-
5	Factory Accident	606	616	0.3	0.31
6	Railway Accident	18340	16452	9.6	8.19
7	Air Cash	80	10	0.0	0.0
8	Fire	23323	22922	12.2	11.41
9	Drowning	23050	25087	12.1	10.57
10	Poisoning	13752	14861	7.2	7.39
11	Snake Bite	4502	5274	2.4	2.63
12	Killed by Animal	974	804	0.5	0.40
13	Boat Capsize	371	1076	0.2	0.54
14	Mine or Quarry Disaster	506	349	0.3	0.17
15	Electrocution	3502	3861	1.8	1.92
16	Fall from Height	4267	4538	2.2	2.26
17	Consuming Spurious Liquor	961	1964	0.5	0.98
18	Suffocation due to Smoke etc.	405	444	0.2	0.22
19	Abortion	162	372	0.1	0.19
20	Unspecified Causes	35288	28223	18.5	14.05
	Total (B)	**185996**	**200887**	**97.7**	**100.0**
	Grand Total [(A) + (B)]	**190435**	**222487**	**100.0**	**200.0**

Source : LP News, Oct-Dec 1996, Oct – Dec 1998 and Jan-Mar 1999.
Note : Percentage less than 0.05 is also shown as 0.0

Table 5.8: Industrial Injuries in India, Cause wise

Cause			1990			1991		
			Fatal	Nonfatal	Total	Fatal	Nonfatal	Total
1	Prime Movers		3	194	197	1	648	649
2	Machinery moved by Mechanical Power							
	a.	Transmission Machinery	38	1682	1720	28	1219	1247
	b.	Lifting Machinery	13	506	519	2	277	279
	c.	Machine Tools for Metal Working	12	3113	3125	11	2992	3003
	d.	Wood Working Machinery	6	509	515	5	378	383
	e.	Other Machinery	16	28333	28349	11	7305	7316

3	Machinery not moved by Mechanical Power	17	1477	1494	5	1444	1449
4	Transport whether moved by Power or not						
	a. Railways	6	398	404	3	213	216
	b. Others	17	2199	2216	19	721	740
5	Electricity	59	576	635	36	408	444
6	Explosions	58	185	243	30	230	260
7	Fires	581	319	370	64	229	293
8	Gassing	19	247	266	15	264	279
9	Molten material and other hot or corrosive substances	42	3618	3660	17	1928	1945
10	Hand Tools	9	10571	10580	5	3314	3319
11	Falling Bodies	20	11647	11667	33	4706	4739
12	Persons Falling	103	10993	11096	82	3950	4032
13	Stepping on or Striking against Objects	33	14899	14932	11	4982	4993
14	Handling Goods or Articles	44	16540	16584	19	9249	9268
15	Others	97	19490	19587	87	15723	15810
	Total	**663**	**127436**	**128099**	**484**	**60098**	**60582**

Source : Indian Labour Statistics 1991-93.

Table 5.9 : Frequency Rates (FR) of Injuries in Factories in India, per one lakh Man-days worked (For some Industries only)

Industry Code No. NIC 1987	1990			1991		
	Fatal	Nonfatal	Total	Fatal	Nonfatal	Total
20-21	0.25	6.58	6.83	0.11	2.58	2.69
22	0.02	3.01	3.03	0.01	1.78	1.79
23	0.03	25.08	25.11	0.02	19.82	19.84
24	0.06	7.93	7.99	0.07	5.78	5.85
25	0.02	41.90	41.92	-	36.89	36.89
26	0.06	4.28	4.34	0.17	0.46	0.63
27	0.03	4.33	4.36	0.02	2.38	2.40
28	0.06	5.86	5.92	0.04	4.87	4.91
29	0.07	1.80	1.87	-	0.59	0.59
30	0.10	5.31	5.41	0.10	10.08	10.18
31	0.14	10.88	11.02	-	-	-
32	0.09	8.53	8.62	0.06	7.44	7.50
33	0.14	8.75	8.89	0.13	9.23	9.36
34	0.02	3.24	3.26	0.07	9.69	9.76
35-36	0.01	1.91	1.92	0.03	4.93	4.96
37	0.03	9.75	9.78	0.03	10.5	10.8
38	0.07	11.09	11.16	0.08	11.06	11.14
39	0.01	5.67	5.68	-	0.68	0.68
40	0.14	6.85	6.99	0.14	4.83	4.97
41	0.07	10.58	10.65	0.10	3.61	3.71
42	-	0.09	0.09	-	-	-
43	-	15.70	15.70	-	6.30	6.30
50	-	-	-	-	-	-

Source : Indian Labour Statistics, 1991-1993
N.B. : For Industry Code (NIC – 1987) see Part 3.7 of Chapter - 19.

Table 5.10 : International Comparison – Industrial Accident Rates (Fatal Accidents)

Country	Manufacturing		
	1988	1989	1990
1. Africa			
Egypt	0.10	0.12	0.13
Tunisia	-	-	0.07
2. America			
Canada	-	-	-
USA	0.02	0.02	0.02
3. Asia			
India	0.17	0.15	0.20
Japan	0.01	0.01	0.01
Philippines	0.05	0.09	0.05
Pakistan	0.56	0.16	-
4. Europe			
France	0.06	0.06	0.06
Germany (Fed.Rep)	0.07	0.07	0.07
Italy	0.02	-	-
Poland	0.08	0.08	0.05
U.K.	0.02	0.02	0.02
Yugoslavia	0.05	-	-
5. Oceania			
Australia	-	-	-
New Zealand	0.06	0.11	0.04

Source : Pocket Book of Labour Statistics, 1995

Table 5.11 : Compensated Injuries and Amount of Compensation paid under the Workmen's Compensation Act, 1923, in All Industries.

Type of Injury	No. of Compensated Injuries		Amount of Compensation Paid (Rs. Lakhs)	
	1991	1992	1991	1992
1. Death	1409	1503	720.86	807.43
2. Permanent Disablement	1538	1365	246.39	233.36
3. Temporary Disablement	10597	7377	103.69	113.55
Total	**13544**	**10245**	**1070.94**	**1154.34**

Source : Pocket Book of Labour Statistics, 1995

Table 5.12 : Maternity Benefit paid under the Maternity Benefit Act, 1961

Area & year	Factories				Plantations			
	Average No. of women employed	No. of women who claimed Maternity	No. of women who were paid maternity	Total Amount paid (Rs. In Lakhs)	Average No. of women employed.	No. of women who claimed maternity	No. of women who were paid maternity	Total Amount paid (Rs. In Lakhs)

		Benefit	benefit			benefit	benefit	
All India								
1988	247941	1366	1204	34.61	274087	30283	22932	257.16
1989	307043	1653	1409	39.77	157455	27207	23002	273.46
1990	243184	1321	1087	34.95	180791	23503	19478	255.31
1991	233502	1172	948	42.94	228484	38130	35818	598.05
1992	209076	1214	1104	59.44	157711	20773	18887	370.08
Gujarat								
1988	-	-	-	-	-	-	-	-
1989	26258	244	233	1.97	-	-	-	-
1990	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-

Source : Indian Labour Statistics, 1991-93.

Table 5.13 : Number of Factories and Employees covered under Employee's State Insurance Scheme

Area & Year (as on 31^{st} March)	No. of centres	No. of factories	No. of employees ('000)	No. of insured persons ('000)	Family (insured Persons) Units ('000)	No. of Beneficiaries ('000)
All India						
1989-90	577	127982	6107	6909	6909	26807
1990-91	589	132878	6070	6894	6894	26748
1991-92	603	141339	5359	6109	6109	23703
1992-93	610	150349	6691	7444	7444	28883
Gujarat						
1989-90	26	9867	650	690	690	2677
1990-91	26	10716	650	690	690	2677
1991-92	27	11335	510	582	582	2258
1992-93	27	11826	548	620	620	2468

Source : Indian Labour Statistics, 1991-93.

Table 5.14 : Cash and other Benefits given under the Employees State Insurance Act, 1948.

Area & year	Attendance at Dispensaries in respect of insured Persons ('000)	No. of cases admitted in Hospitals	No. of Domiciliary visits paid to insured Persons	Disablement Benefits		
				Claims Admitted	Amount of Temporary Disablement Benefits paid	Capitalized value of permanent Disablement Benefits claims Admitted
1	2	3	4	5	6	7
All India						**(Rs. In Lakh)**
1990-91	31797	257056	191071	271364	1103.05	2022
1991-92	30374	357764	192852	203175	993.27	2344
1992-93	31353	377904	184148	310540	2134.66	2337
Gujarat						**(Rs. In Thousand)**
1990-91	2399	16339	656	27099	8256	13047

1991-92	2134	16293	482	20767	8520	17971
1992-93	2235	17435	343	29785	14812	17597
	No. of Fresh claims paid ('000)	Total amount paid (Rs. Lakh)	No. of confinements	Total amount paid (Rs. Lakh)	Total of death cases Admitted	Capitalized value of Benefits claims Admitted
1	8	9	10	11	12	13
All India						**(Rs. In Lakh)**
1990-91	18	2913.75	17376	362	994	865.16
1991-92	17	3417.73	19717	447	1034	944.93
1992-93	14	3359.74	20832	499	1089	1211.81
Gujarat						**(Rs. In Thousand)**
1990-91	79	15859	927	2079	113	9360
1991-92	66	16714	910	2438	111	10911
1992-93	50	13813	1001	2652	131	16775

Source : Indian Labour Statistics, 1991-93.

Table 5.15 : Registered Factories and Workers in Gujarat under the Factories Act.

↓ Year → Section	1999	2000	2001	2002	2003	2004	2005
2 (m) (i)	21204	21996	22272	22882	23291	24046	24408
2 (m) (ii)	1000	1001	993	982	1070	1220	1241
85	3441	3457	2824	4038	4192	4382	4461
Total Factories	24645	26454	27094	27904	28553	29648	30110
Total Workers	864674	868000	777597	815462	876483	826516	1080452
No. of Inspection	15235	15245	16998	16361	18708	14751	17087
No. of Prosecution	2222	1941	2355	1370	1886	2200	2070

Source : Office of the CIF, Ahmedabad.

Table 5.16 : Industry group wise Registered Factories & Workers in Gujarat (as on 31-12-2001)

NIC Code	Working Factories	Average Workers	NIC Code	Working Factories	Average Workers
10	2	133	34	127	5651
11	8	439	35	230	14144
13	1	19	36	374	15032
14	15	550	37	16	480
15	1855	84806	40	44	13050
16	201	8250	41	25	890
17	2634	163714	45	7	209
18	170	9284	50	261	13852
19	50	8289	51	18	872
20	798	12314	52	131	6064
21	468	16475	55	2	124
22	312	8268	60	17	857
23	164	20522	63	55	894

24	3676	159601	66	1	4
25	1021	39024	71	1	23
26	1936	65932	72	3	161
27	1432	54395	73	8	397
28	1723	46568	74	13	469
29	1906	62219	75	2	75
30	29	1293	80	63	2909
31	472	23510	90	13	386
32	87	6474	91	1	14
33	150	6435	92	1	9
			93	38	1388
			Total	**21220**	**907101**

Note : For description of NIC Code see part 3.7 of Chapter – 19.

Source : Office of the CIF, Ahmedabad.

Table 5.17 : District wise Factories in Gujarat, in 1997.

No.	District	Total Factories	Working Factories	Total Average Daily Employment
1	Ahmedabad City	5419	4150	160679
2	Ahmedabad Rural	922	767	40208
3	Amreli	51	26	1950
4	Anand	742	560	25437
5	Banaskantha	47	36	1537
6	Baroda	2754	2250	109578
7	Bharuch	1275	1103	49303
8	Bhavnagar	719	537	28139
9	Dahod	53	49	2157
10	Dang	4	4	101
11	Gandhinagar	251	193	11388
12	Jamnagar	718	453	20631
13	Junagadh	486	406	23258
14	Kachcha	322	234	14203
15	Kheda	429	306	13535
16	Mehsana	1232	1095	44553
17	Narmada	20	15	2427
18	Navasari	557	389	14767
19	Panchmahal	538	443	21291
20	Patan	133	112	2873
21	Porbandar	77	58	5371
22	Rajkot	1892	1667	44221
23	Sabarkantha	223	208	12982
24	Surat	2718	2102	122796
25	Surendranagar	739	559	21270
26	Valsad	2026	1669	60419
	Total	**24347**	**19381**	**855079**

Source : Office of the CIF, Ahmedabad.

Table 5.18 : Fatal & Nonfatal Accidents, Frequency and Severity Rate and Percentages from Reported Accidents in Gujarat.

Year	No. of Persons injured		Total	FR	SR	% of machinery accidents of all accidents	% of only textile machinery accidents to total textile accidents
	Fatal	Nonfatal					
1993	184	17026	17210	14.04	0.66	19.26	24.28
1994	194	15489	15683	14.20	0.71	30.07	21.37
1995	192	13068	13260	10.14	1.07	15.64	18.97
1996	183	11072	11255	13.19	1.09	15.24	19.25
1997	246	11885	12131	13.88	1.14	17.38	18.48
1998	223	11930	12153	9.93	0.49	9.3	9.85
1999	211	10513	10724	7.89	0.45	5.36	4.54
2000	232	8584	8816	11.25	1.06	15.25	15.25
2001	176	6542	6417	7.52	1.08	8.69	10.97

Source : Office of the CIF, Ahmedabad.

Table 5.19 : Textile and Non-textile Accidents in Gujarat.

Year	Textile Accidents			Non-textile Accidents			Grand Total
	Fatal	Nonfatal	Total	Fatal	Nonfatal	Total	
1993	29	9230	9259	155	7796	7951	17210
1994	33	6416	6449	161	9073	9234	15683
1995	17	8210	8227	175	4858	5033	13260
1996	32	3978	4010	151	7094	7245	11255
1997	36	6967	7003	210	4857	5067	12070

Source : Office of the CIF, Ahmedabad.

Table 5.20 : Cause wise Fatal Accidents in Gujarat

No.	Main Cause	1993	1994	1995	1996	1997
1	Transmission machinery	4	11	-	-	2
2	Machinery run by power	10	2	12	17	45
3	Machinery not run by power	4	5	2	1	2
4	Transport (Material Handling)	16	7	6	4	2
5	Electricity	15	21	14	19	10
6	Fire / Explosion	12	20	12	3	25
7	Toxic gas exposure	4	10	7	12	5
8	Molten metal and other hot substances	33	17	5	15	3
9	Hand tools	-	-	12	9	12
10	Struck by falling body	9	12	11	4	18
11	Falling from height	47	17	125	16	10
12	Striking against object, falling, slipping etc.	5	24	28	32	39
13	Manual handling	5	-	16	16	12
14	Lifting machinery not run by power	2	5	8	3	6
15	Others	18	43	34	32	55
	Total	**184**	**194**	**192**	**183**	**246**

Source : Office of the CIF, Ahmedabad.

Table 5.21 : Industry – group and Sex wise Accidents in 1997 in Gujarat.

Industry Code NIC – 1987	Male		Female		Total	
	Fatal	Nonfatal	Fatal	Nonfatal	Fatal	Nonfatal
20-21	13	110	1	2	14	112
22	-	-	-	-	-	-
23	16	5786	8	131	24	5917
24	23	1763	-	2	23	1765
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	2	249	-	1	2	250
28	7	61	-	2	7	63
30	55	547	3	-	58	547
31	18	445	-	22	18	467
32	8	354	2	1	10	355
33	13	470	-	-	13	470
34	6	191	-	4	6	195
35-36	6	645	-	13	6	658
37	56	122	-	-	56	122
38	1	101	-	-	1	101
40	7	620	-	33	7	653
97	1	210	-	-	1	210
Total	**232**	**11674**	**14**	**211**	**246**	**11885**

Source : Office of the CIF, Ahmedabad.
Note : For Industry Code (NIC – 1987) See Part 3.7 of Chapters – 19.

Table 5.22 : Industry-group and Cause wise Accidents in 1994 in Gujarat.

Industry group * NIC – 1987	Accident Classification as per Factory Inspectorate, Gujarat and Number of Accidents					
20-21	101-3	103-2	104-1	106-2	109-4	112-4
	117-1	119-2	120-24	121-19	123-5	124-13
	125-13	126-8	127-10	128-2	129-23	130-15
	131-62	Total-212				
22	102-1	103-1	22-1	Total-3		
23	101-2633	102-956	103-7	104-17	105-16	106-43
	107-3	108-2	109-5	112-356	113-81	114-36
	115-65	116-80	117-21	119-6	120-4	121-59
	122-64	123-69	124-300	125-474	126-227	127-243
	128-92	129-529	130-459	131-1250	Total-8097	
24	101-63	103-1	106-2	111-4	112-14	113-47
	114-28	115-25	116-53	117-14	118-2	119-38
	121-21	122-47	123-40	124-42	125-95	126-19
	127-17	128-89	129-175	130-70	131-62	Total-994
25	120-29	124-2	126-2	131-1	Total-34	
26	110-1	131-2	Total-3			
27	101-1	110-1	124-1	131-7	Total-10	
28	101-8	104-3	106-4	111-5	112-5	113-1
	117-1	118-6	119-2	120-5	121-10	123-1
	124-4	125-12	126-3	127-3	129-10	130-7

	131-25	Total-125				
30	101-2	102-24	103-1	104-1	105-2	106-4
	107-1	110-1	112-5	115-2	116-9	117-17
	118-8	119-13	120-45	121-108	122-3	123-36
	124-27	125-46	126-40	127-25	128-26	129-62
	130-42	131-593	Total-1143			
31	101-1	102-3	105-10	106-2	107-1	108-1
	110-1	112-22	114-1	117-3	118-8	119-3
	120-2	121-47	122-2	123-16	124-30	125-13
	126-12	127-47	128-44	129-133	130-70	131-73
	Total – 545					
32	102-15	103-3	104-2	105-2	106-6	107-2
	108-1	109-1	112-6	114-1	115-1	116-1
	117-6	118-6	119-3	120-1	121-15	123-61
	124-10	125-43	126-41	127-18	128-20	129-176
	130-72	131-295	Total-807			
33	101-5	102-1	104-3	105-2	106-11	107-2
	111-1	112-5	116-1	117-4	108-1	119-1
	120-3	121-118	122-71	123-89	124-30	125-119
	126-3	127-4	128-5	129-168	130-31	131-210
	Total - 888					
	101-2	102-3	103-3	105-7	106-31	109-2
	110-1	111-1	112-10	117-4	118-1	119-2
	120-16	121-30	122-59	123-54	124-39	125-27
	126-19	127-9	128-5	129-32	130-39	131-90
	Total -485					
	102-6	103-1	104-2	105-6	106-69	110-1
	112-10	117-4	118-2	119-4	120-5	121-8
	122-142	123-131	124-132	125-75	126-64	127-52
	128-44	129-61	130-8	131-366	Total-1193	
	104-1	112-5	117-2	119-6	120-2	121-8
	125-6	126-4	127-7	129-15	131-20	Total-76
	101-5	102-2	103-2	104-4	105-3	106-16
	109-8	110-11	112-13	114-12	116-5	17-22
	119-14	120-1	121-4	122-5	123-4	124-5
	125-3	126-3	127-3	128-6	129-21	130-7
	131-8	Total-187				
	104-1	106-5	112-1	117-10	119-2	121-40
	123-4	124-46	125-44	126-44	127-33	128-3
	129-53	130-103	131-124	Total-513		
	101-26	103-12	104-12	105-4	106-1	108-20
	112-8	117-2	118-3	120-23	121-10	122-2
	123-81	124-29	125-10	126-17	127-3	128-2
	129-14	130-26	131-143	Total-368		
	101-2749	102-1011	103-33	104-47	105-52	106-196
	107-9	108-24	109-20	110-17	111-11	112-464
	113-129	114-78	115-93	116-149	117-111	118-37
	119-96	120-160	121-497	122-395	123-511	124-710
	125-980	126-506	127-474	128-338	129-1472	130-949
	131-3342	Total-15683				

Source : office of the CIF, Ahmedabad.

NB : (1) * For NIC - 1987 see Part 3.7 and for Accident Classification see Part 3.6.2 of Chapter-19.

(2) Figures group '101-1' means I accident (fatal+ nonfatal) of causation number 101 i.e prime movers, '117-21' means 21 accidents due to causation No. 117 i.e. electricity.

Conclusion of the above Statistical Tables :

(A) At All India Level (based on past figures) :

1. The highest number of factories are in Bihar, then in Maharashtra and Andhra Pradesh at second and third number. Considering Table 5.15, Gujarat is at No. 4. Employment wise Maharashtra, West Bengal and UP are at No. I, 2, and 3, and Gujarat stands at No. 4 (Table 5.1, 5.15 and 5.16).

2. After 1986 to 1991, number of injuries, incident rates (IR) and frequency rates (FR) have been decreased indicating an improved safety performance at all India level. But as mentioned by the source, ten to eleven States (including UP, Bihar, Karnataka, Delhi, Tamil Nadu, West Bengal etc.) had not sent the information for some or the other years. Therefore the inference remains incomplete (Table 5.2).

3. Comparing Gujarat with Maharashtra, MP, Orissa and Tamil Nadu, Gujarat has higher rate of fatal accident and therefore needs more attention (Table 5.4).

4. In 1992, in fatal and nonfatal accidents, Maharashtra was the first and Gujarat was second. in India. Considering injuries per 1000 workers, MP was the first and Rajasthan was second (Table 5.5)

5. Industry wise, in 1992, the highest fatal accidents were in basic metal industry, then in chemical and then in textile industries. Nonfatal accidents were highest in textiles, then in basic metal, machinery and equipment. Considering per thousand workers, fatal incidence rate was highest due to electricity, gas and steam, while non-fatal incidence rate was highest in basic metal industry and lowest in textile industry. Frequency rate (injury per one lakh man-days worked) is the highest in textile industry in respect of non-fatal accidents (Table 5.6).

6. Percentage wise highest fatal accidents are due to road accidents (27.2%). Then comes the causes of fire (12.2%), drowning (12.1%) and railway accidents (9.6%). Factory accidents are only 0.3%.Urispecified causes, being 18.5%, need detailed classification (Table 5.7, year 1994).

7. Causation wise in both the years 1990 and 1991, the highest fatal accidents were due to persons falling, then due to fires and electricity in descending order. The highest non-fatal accidents were due to material handling and machinery moved by mechanical power (Table 5.8).

8. The highest frequency rate in 1990 and 1991, was in Jute and cotton textile industry and the lowest in water works and leather works (Table 5.9).

9. International comparison states that Japan has the lowest fatal accident rate. Then comes USA and UK, both, at No. 2. India and Pakistan have the highest fatal accident rate! (Table 5.10).

(B) At Gujarat Level (based on past figures) :

1. Factories have been continuously increased in Gujarat from 24645 (in 1999) to 30110 (in 2005). The highest number of factories are in Ahmedabad city and then in Surat, Valsad and Vadodara districts in descending order (Table 5.15,5.16,5.17).

2. Fatal accidents varied between 246-175 (during 1997-2001). Non-fatal accidents seem to be decreasing. FR and SR indicate that frequency and severity are slightly increasing. In 1993 and 1995, non-fatal accidents were more in textile industry. But in 1994 and 1996 the scene was reversed (Table 5.18 & 5.19).

3. Causes of fatal accidents show that, during 1993 to 1997, the highest fatal accidents have happened due to –

1.	Striking against objects, falling	-	128
	on the flat, slipping etc.	-	115
2.	Falling from height	-	86
3.	Machinery run by power	-	79
4.	Electricity Molten metal and hot substances	-	73
5.	Fire and explosion	-	72

Then comes the causes of manual handling and struck by falling body.

If accidents classified as 'others' are exactly classified to the nearest specific cause, more fruitful information can be available (Table 5.20).

4. Industry wise majority (49.78%) of the total accidents in Gujarat are in cotton textile factories. Next in descending order are in engineering, chemical, silk, wool and synthetic fibre, basic metal, alloy and non-metallic mineral products, rubber, plastic and electricity factories. Other types of factories contribute less accidents (Table 5.21).

5. Causation wise the highest accidents (fatal ani •non-fatal) in Gujarat, m 1994, (See Table 5.2 and Part 3.6.2 of Chapter-19) were -

1.	Miscellaneous (not classified elsewhere)	3342
2.	Prime movers	2749
3.	Stepping on or striking against objects	1472
4.	Shafting and Transmission machinery	1011
5.	Struck by falling body	980
6.	Material handling	949
7.	Use of hand tools	710
8.	Falling from height	506
9.	Molten metal and hot substance	497
10.	Falling on the flat	474
11.	Lifting m/c (not moved by power)	395
12.	Falling into pits, excavation etc.	338

Other causes such as gas, fire, explosion etc. are still in descending order.

This analysis reveals that non-chemical causes contribute much more accidents than those contributed by chemical causes. This may be due to more manpower employment in non-chemical factories (about 30% in textiles, 10% in chemicals and 60% scattered in various other industries) and even in chemical factories not all workers exposed to chemicals. This should not result in under-estimating the high potentiality of chemical hazards. Many disasters have proved this fact. It is good that their frequency is less.

6. Major causes of non-fatal accidents are miscellaneous (others) in textile and non-textile factories, stepping on or striking against object, material handling, struck by falling bodies, use of hand

tools, falling on the flat, hot or corrosive substances, machine tools, falling from height and machinery moved by mechanical power.

7. Looking to the number of Safety Officers employed in some big factories, Gujarat is in good position. But it is noticeable that importance of safety officers is still not recognised. It is in the interest of safety to employs requisite safety officers to work exclusively for safety and accident prevention work Head of the Safety Department should be considered at par with other departmental heads and directly reportable to the top executive.

8. It is easily inferred from the above statistics that -

1 Textile, Chemical and Engineering factories should be the main target of accident prevention activities.

2 Most of the accidents are easily preventable by good- housekeeping training of workers, engineering controls and use of personal protective equipment, and

3 The safety statistics must be more accurate, because, majority accidents classified as 'miscellaneous' or 'others' suggest nothing specific and the accident prevention work becomes helpless in that dark (undetected) area. This visualises the importance of such safety statistics and their inference.

13. MANAGEMENT INFORMATION SYSTEM (MIS) FOR SAFETY

Management Information System (MIS) has become a powerful tool for industry, trade and business in the modern world. It should be user friendly and easy to understand. With the Age of Computers, the speed, capacity, accuracy and a variety of uses of Information has been tremendously increasing in almost all walks of life. Computers are useful not only for storing information but also for generating data, designing, programming, processing, controlling, running robots and microprocessors, communication, developing science, technology and management systems, analysing and using information, forecasting and personal use. We have entered the age of internet, web-site and information highways. The information (data-processing) must be accurate, pertaining to the point, concise, updated, meaningful, trust worthy and as per the need of the user.

The area of Safety, Health & Environment has also been delighted by an entry of computers and internet. The huge amount of information on accident statistics, health data and environmental aspects can, now, be easily stored, analysed, transmitted and used for many purposes. However in our country the use of computers for these areas is yet to be developed in majority of factories, particularly in medium-scale and small ones. Software should be developed for information in this vital area of safety, health and environment.

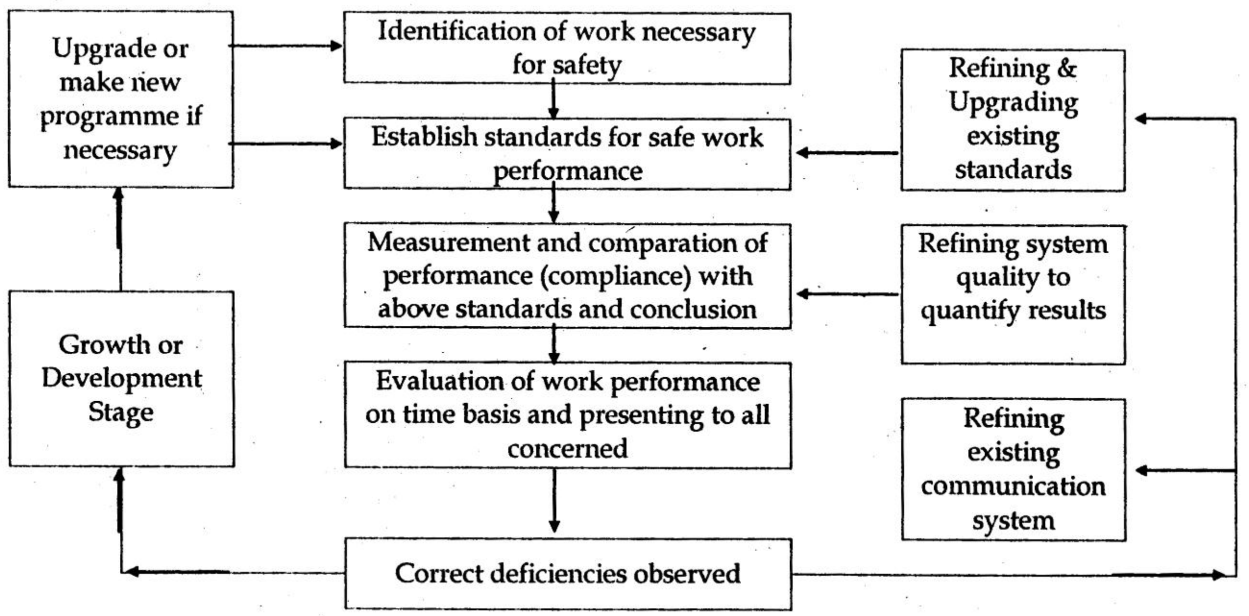
There should be effective MIS between Safety Department and the top management of the company to appraise the work being done by the Department. Similarly it should also be developed/extended for bottom line management and the outside authorities to provide quick and tabulated information in wide areas of safety, health & environment.

Computer, FAX, Internet, E-Mail and V-mail system can be used to devise various formats, tables, charts, symbols, graphs and documents to report, analyse, reply and store the information pertaining to accidents, statutory requirements, compliance, training programmes, safety meetings, future planning, budgeting, monitoring, work permit systems, safety appraisal reports, safety audits etc.

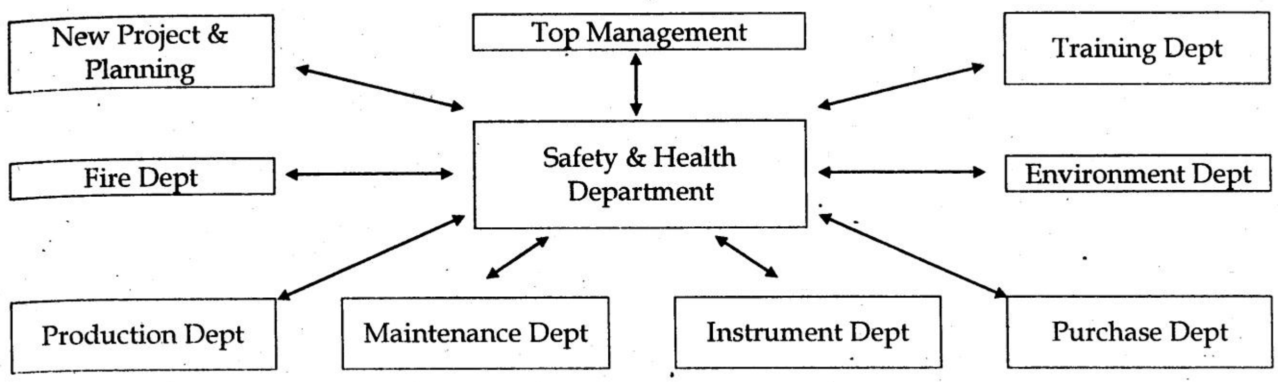
Types of information for safety may be of the following kind:

	Type	Examples
1.	Operational	Process control, fire protection system, inspection reports, test reports, environmental monitoring, training programmes etc.
2.	Legal (statutory)	Legal reports, returns, annexure. updated law. etc. regarding accident information industrial activity, compensation etc
3.	Tactical	Required for immediate need e.g procurement of safety equipment assessing training needs, daily reports etc.
4.	Strategic	Required for long term planning e.g on-site, off-site emergency plan layout planning.

MIS for SMS : MIS for Safety Management System should be designed as per own need. One general model may be of the following type :



A loop of effective communication system with safety department should be effectively arranged based on existing organisation set-up. A simple chart may be as under :



13.1 Sources of Information on Safety, Health & Accidents :

In our country the main sources to get such information are as under :

1. The Labour Bureau, Shimla & Chandigadh. Their state offices.
2. The Bureau of Indian Standards with its HQ at Delhi, four regional offices and some branches and inspection offices in major cities.
3. Loss Prevention Association of India with its offices at Bombay, Calcutta, Cochin, Hyderabad, Madras, Delhi and Visakhapatnam.
4. National Safety Council with its HQ at Bombay and Chapters in some cities.
5. The Central Labour Institute with its HQ at Bombay and Regional Labour Institutes (RLIs) at Calcutta, Kanpur and Madras.
6. National Institute of Occupational Health (NIOH), Meghaninagar, Ahmedabad - 380016.
7. The Mahatma Gandhi Labour Institute, Thaltej Road, Ahmedabad-380052.
8. Ministry of Environment & Forests, New Delhi.
9. Safety and Health Information Bureau, Sector 16, Vashi, New Bombay - 400 705.
10. Gujarat Safety Council, 4'h floor, Midway height, beside Panchmukhi Hanuman Temple, Near Kirty mandir, Kala Ghoda, Vadodara- 390 023.
11. The Council of Industrial Safety, Elphinstone Building, 10, Nariman Road, Fort, Bombay 400023.
12. The Safety First Association of India, 2nd floor, Stadium House, Nariman-Rd., Fort, Bombay 400023.
13. Directorate General of Mines Safety, Dhanbad826004, Bihar.
14. Ahmedabad Textile Industries Research Association (ATIRA), near Gujarat University, Navarangpura, Ahmedabad-380009.
15. National Institute of Training for Industrial Engineering (NITIE), Vihar Lake Rd., Bombay-400087
16. National Environmental Engineering Research Institute (NEERI), Nagpur-440010.
17. Indian Association of Occupational Health, C-62, Defence Colony, New Delhi-110024.
18. Industrial Health Organisation, Babu Vihar, 7/198, Swaroopnagar, Kanpur, UP.
19. Department of Industrial Health, Tata Services Ltd., Jeevan Vihar, 75, Apollo Street, Fort, Bombay-400 023.
20. Industrial Toxicology Research Centre, P.B. No. 80, Lucknow-226001.
21. Indian Council of Medical Research, Ansarinagar, Medical Enclave, New Delhi.
22. All India Institute of Hygiene and Public Health, 110, Chittaranjan Avenue, Calcutta-700012.
23. Occupational Health Research Institute, C/o BJ Medical College, Ahmedabad-380016.
24. Safety, Health & Environment Association, 2nd Floor, Vadilonu Ghar, Kasak Fuvara, Bharuch 392012, Gujarat.
25. Kamdar Swasthya Suraksha Mandal, Opp ESIS General Hospital, Gate No. 2, Bapunagar, Ahmedabad - 380 024.
26. Vyavsayik Swasthya Suraksha Mandal, 43, Shrinathdham Duplex, Swami Shivanand Road, B/h Dinesh Mills, Vadodara- 390007.
27. Greentech Foundation, 809, Vishwadeep Tower, Distt Centre. Janakpuri, New Delhi - 110058 (Website: www.greentech.org.)
28. Master of Industrial Hygiene and Safety Division, ISTAR Building, Vallabh Vidyanagar - 388120, Dist- Anand, Gujarat.
29. HSE Information Services, Caerphilly Business Park, Caerphilly CF83 3GG, UK.
30. Internet, websites and computer software are now available on the subjects of industrial safety, health and environment including that of British Safety Council, London, National Safety Council, USA, CSP (Certified Safety Professional) and CIH (Certified Industrial Hygienist) Examinations etc. See part 13.2 also.

The publications and periodicals of above institutions and Offices of the Labour Departments and Pollution Control Boards of various States also provide information on safety, health and environment.

NSC, USA publication 'Accident Facts' gives wide information on accident statistics of USA every year.

Some International organisations are as under :

1. International Labour Organisation (ILO), Geneva, Switzerland (Office in India at - 7, Sardar Patel Marg, New Delhi-110021).

   It has a separate branch for occupational safety and health. For collection and dissemination of Occupational safety and health information, it functions through

   1) International Occupational Safety and Health Information Centre (CIS)
   2) International Programme on Chemical Safety (IPCS) at WHO, HQ, Geneva.
   3) International Occupational Safety and Health Hazards Alert Systems. It is a part of the ILO International Programme for the Improvement of Working Conditions and Environment (PIACT).
   4) Clearing House for dissemination of information on condition of work.

   ILO publication **"Encyclopaedia of Occupational Health and Safety"** is worth mentioning for its great service on such information to the world.

2. World Health Organisation (WHO), Geneva, Switzerland (Office in India at World Health House, Indraprastha Estate, Ring Road, New Delhi-110002).
3. United Nations Environment Programme (UNEP)
4. Health and Safety Executive (HSE), Information Centre, Broad Lane, Sheffield 53 7HQ (UK).

There are many other such organisations in many countries of the world.

See reference mentioned at the end of each chapter, particularly of Chapter - 18 and 19., for ample material on health and safety.

In addition to law books, standards, codes, periodicals and publications (books), research reports, seminar or symposia reports, inspection or audit reports, accident case studies, meetings of specialists or experts and training programmes are also the main vehicles for the exchange of information on health, safety and environment.

Modern software like CAMEO, EFFECT, WHAZAN, HEGADIS, SAFETI, PHAST, BLEVE and Explosion packages -IIT, Kanpur, ALOHA, ARCHIE, CIRRUS etc. should be utilised and updated. Safety Data Banks should be created at National and State level. Global internet system should be utilised. MIS should be interlinked with National SHE System at all strategic areas.

Thus sufficient information is available from above sources. Only need is to implement it at the shop floor levels.

13.2 Websites on Safety -

Out of many websites on safety and health, some are mentioned below-

1. Chemical safety - www.chemicalsafety.co.in
2. Young Worker Health and Safety www.youngworkers.org
3. CROET Health & Safety Information www.ohsu.edu/ croet
4. Online purchasing of hundreds of safety products - www.compliancesafety.com
5. Risk Control Rating Systems (South Africa) www.rcrs.co.za
6. Free Safety Programs, Training Material, and Safety Information for Business & Industry www.safetyinfo.com
7. Applied Safety and Risk Management (Australia) - www.aplied-safety.com
8. Ergonomics web site with a lot of free Program, Training, ClipArt, Compliance information www.ergonext.com

9. On-line databases of information and downloadable software related to the environment, health & safety. www.ehsfreeware.com
10. National Safety Council, USA - www.nsc.org
11. NYCOSH website - www.nycosh.org
12. Det-Tronics, manufacturer of fire and gas safety systems - www.detronics.com
13. American Bio safety Association www.absa.org
14. Centres for Disease Control - www.cdc.gov/cdc.html
15. Electrical Safety Forum site - www.electricalsafety.com
16. Fall protection - Dynamic Scientific Controls www.fallsafety.com
17. University Safety Program- Florida State University - www.fsu.edu/~safety/
18. MSDS Surfer:
    Harvest MSDSs from the world-wide-web www.msdssurfer.com
19. MSDS Solutions - www.msdssolutions.com
20. The Computerized IH Data Management System - www.cihsystem.com
21. Safety Assistant (Australian Software for Workplace Health & Safety) www.safetyassistant.com.au/
22. MSDS FAST SEARCH database of over 230000 MSDS's from Envirowin - www.envirowin.com / 10196e.htm
23. Industrial Hygiene Java Scripts www.industrialhygiene.com/
24. International Product Safety News - www.safetviink.com
25. International Radiation Protection Association (IRPA) - www.irpa-exof.nl/
26. OSHA DATA (searches of OSHA enforcement data) - www.oshadata.com
27. Fire web - www.fireweb.com
28. National Fire Protection Association, USA -
    (1) www.nfpa.org.
    (2) www.wpi.edu/ ~fpe/nfpa.html
29. LEPC net - www.rtk.net/lepc.net
30. U.S. Chemical Safety and Hazard Investigation Board - www.chemsafety.gov
31. Pesticides - www.sis.nlm.nih.gov/enviro/ pesticides.html.
    - www.cdc.gov/niosh/topics/pesticides/
32. Indoor Air - www.who.int/indoorair/en/
33. Respirator selection - www.cdc.gov/niocs/2005-100/
34. Air Sampling Direct Reading - www.skcinc.com/reference.asp
35. CIH exam preparation - www.abih.org/
36. Advanced topics
    - www.cdc.gov/niosh/homepage.html
    - www.osha.gov/
    - www.aiha.org/content
37. Ergonomics - www.ergonomics.org.uk/ - www.ergonomics.com.au/
38. Emergency Planning and Preparedness - Websites http://globalcrisis.info/ emergencycontro1centers.html#E
39. National Institute of Disaster Management http: / / www.ni dm. net/ index.htm
40. Useful Websites as per National Institute of Disaster Management http://www.nidm.net/usefullinks.asp
41. Industrial Disaster Management Information System by Gov t. of Gujarat.
    http://www.labour&emplovment.gov.m/idmis
42. International Safety Cards By I.L.O.
    http://www. ilo.org/encyclopaedia/?d&:nd=857090010&prevDoc=857000002
43. Fact Sheet of Hazardous Chemicals
    http://web.doh.state.nj.us/rtkhsfs/factsheets.aspx?lan=english&alph=A&carcinogen=false&new=false
44. NIOSH Pocket Guide to Chemical Hazards http://www.cdc.gov/niosh/npg/npgnamea.html
45. Chemical and other safety information – Oxford ' http://physchem.ox.ac.uk/MSDS/

46. M.S.D.S. and Emergency Response for different chemicals Guide – Download http://hazmat.dot.gov/pubs/erg/psnsort.htm
47. Occupational Safety and health topics by NIOSH http://www.cdc.gov/niosh/topics/ http: / / www.cdc.gov/elcosh/ docs/ other/ cdrom software.html
48. Government and Profit Sites http:/ /www.ilpi.com/msds/#Government
49. IPCS INTOX: Databank http://www.mtox.org/databank/mdex.htm
50. IPCS INTOX: Chemical Databank http: / /www.mtox.org/ databank/ pages/ chemical.html
51. Chemical Safety Information http://www.mchem.org/
52. Chemical Safety Reference Databases http://www.safety.vanderbilt.edu/ safety_links/chemsafetydata.htm
53. First aid, & Medical emergency guide http://www.medmdia.net/patients/firstaid.htm
54. Chemical Emergency Preparedness, Prevention & First Aid for Extremely Hazardous Substances U.S. Environment Protection Agency http://yosemite.epa.gov/oswer/ceppoehs.nsf/ Alphabetical_Results?openview
55. Explosion Database of Chemicals- NIMCK- Japan http://www.aist.go.jp/RIODB/db005/ index.html
56. Incompatibility of Chemicals http://www.pp.okstate.edu/ehs/hazmat/ labman/ Appendix-B.htm
57. Laboratory Safety Manual http: / / www. pp.okstate.edu/ ehs/hazmat/ labman/Chaplal.him
58. Hazardous Material Incident Toolkit http://www.oes.ca.gov/0perational/ OESHome.nsf/ Content/ 333G7C454B5PC40B882571070069A855?Opei->Documen
59. Hazardous Material Transport Training Module http://hazmat.dot.gov/trainmg/mods/mod.htm
60. Data Sheets of Extremely Hazardous Chemicals by US Environmental Protection Agency http: / / yosemite.epa. gov / oswer/ceppoehs.nsf/ Alphabetical_Results?openview
61. Fact Sheets of Hazardous Substances http:/ /web.doh.state.nj.us/rtkhsfs/ search .aspx?lan=english
62. MSDS by Scott http://www.scottecatalog.com/msds.nsf/ AII?ReadForm
63. Environment, Health &: Safety Online http://www.ehso.com/contents.php#B
64. Poisons' Information monographs- by CCOHS Canada http://www.inchem.org/pages/pims.html
65. Chemical Safety in Asia - Law & Practice- by ILO http://www.ilo.org/public/english/protection/safework/papers/asiachem/index.htm
66. The Chemical Database- By Akron University http://ull.chemistry.uakron.edu/erd/
67. Recurring causes of Chemical Accidents documents http://www.plant-maintenance.com/articles/ccps.shtml
68. Chemical Accident excellent case study by U.S. Chemical Safety and Hazard Investigation Board http://www.csb.gov/
69. Incident Investigation Reports from Chemical Safety and Hazard Investigation Board http://ncsp.tamu.edu/reports/CSB/csbList.htm
70. Ammonia spill incidents summery http://www.mda.state.mn.us/spills/ammonia/summaries.htm
71. Superb presentations and video on safety and accident case study http://www.cdc.pov/elcosh/docs/other/cdrom_software.html
72. Site for Bhopal tragedy case study http://www.cdc.gov/elcosh/docs/other/cdrom_software.html
73. Safety PPT and Posters by Vermont SIRI- superb safety training stuff-free http://siri.uvm.edu/
74. Chemo genesis web book- good knowledge resource http://www.meta-svnthesis.com/webbook.html http://www.safework.sa.gov.au/show_page.1Sp?id=2769
75. Chemical Thesaurus software http://www.chemthes.com/overview.html
76. How to plan work place emergencies document OSHA http://www.osha.gov/Pubjications/ osha3088.html
77. Encyclopedia-chemical accidents http://www.reference.com/browse/wild/Chemical_accidents
78. Download CAMEO software http://www.epa.gov/ceppo/cameo/request.htm
79. Safety information on internet http://hazard.com/course/
80. Superb web links page for safety http://www.hazard.com/links.html
81. Safety Training videos and DVDs availability-OSHA http://www.safetytrainingnetwork.com/
82. Central Crisis Group-India http://envfor.nic.m/divisions/hsmd/red.html#intro

83. Gujarat Safety Council http://www.gscgujarat.com/
84. Mahatma Gandhi Labour Institute http://www.mgliahd.org/
85. National Institute of Health, U.S. http://www.cdc.gov/niosh/homepage.html
86. National Institute of Occupational Health (NIOH) http://www.nioh.org/
87. Directory of Central Government Websites http://www.manupatra.com/about/search.asp#Simple
88. Gujarat State Disaster Management Authority (GSDMA) http://www.gsdma.org/
89. DGFASU http://dgfasli.mc.m/
90. National Safety Council, India http://dgfasli.nic.in/dgfasli/masterdetail2.asp?orgid=4009
91. Controller of Explosives http://explosives.nic.in/
92. Enviornment Department, Govt of India http://envfor.nic.in/
93. Labour Bureau Chandigadh http://labourbureau.nic.in/
94. Website on Safety http://www.safetyforeveryone.coni/doyoukriow/dyk.html
95. For all Pollution Laws text http://edugreen.teri.res.in/explore/laws.htm
96. Portal of Government of Gujarat http://www.guiaratindia.com/
97. PPE Directory http://www.infobanc.com/index_s3.htm
98. Fire Safety Eq. Supplier http://dir.indiamart.com/indiammporters/s_safety.html
99. U.S. Consumer Product Safety Commission www.cpsc.gov
100. American Chemical Society www.acs.org
101. International Agency for Research on Cancer www.iarc.fr
102. Laboratory Safety Institute www.labsafety.org.
103. MSDS Online www.msdsonline.com
104. Safety Information Resources Inc MSDS Collection www.hazard.com

13.3 Compilation, Collation & Analysis of Information:

At a factory or workplace level, information of hazards and past and current accidents should be collected first with facts and details. This is compilation. Then it should be put together subject or major head wise. Then in each head (viz. major hazards, minor hazards, accidents to persons, property losses, costs of accidents etc.), the information should be combined or arranged in a proper order for the purpose of easy understanding or comparing in detail. This is collation of information. Then it should be analysed or classified into subdivisions or subgroups to sharpen the information towards different subjects leading to some conclusion. This is analysis.

As an example, accidents of one particular year are first collected. This is compilation, (viz. Accidents for the year 1996, accidents costs, 1995 etc.). Then they are grouped (combined) together as mechanical accidents, chemical accidents, reportable and non-reportable accidents, fatal and non-fatal accidents, cost calculations etc. This is collation of information. Here comparison is possible. Mechanical accidents of factory A can be compared with those of factory B. If they are arranged in some order, say, date wise or code wise, it is also collation of information. But when the information is classified as male and female wise, day and night wise, different hazard or causation wise, equal cost wise, severity wise, frequency wise, body part wise etc., it is called analysis. This gives sharp or pointed information on a particular point subject to draw some conclusion.

This system of analysing data is useful to find out target areas of work and priority of remedial measures to concentrate on them. Manual exercise is reduced to a great extent if a computer is used for such work.

To foresee future possible hazards or risk estimation, by using various identification, measurement and evaluation techniques (Chapter 19) like HAZOP, HAZAN, fault-tree, event tree, risk and consequence assessment etc., detailed information can be compiled, analysed and used for accident prevention work.

Use of computer makes it easy to compile, collate, analyse and store vast information on identification of major hazard installations, risk analysis, safety audit, preparing on-site and off-site emergency plans, control pleasures, etc. and makes further easy to incorporate any additions and alterations at appropriate places to update the documents.

13.4 Modern Methods of Programming:

Such methods use computer as basic tool and software of required programmes. Therefore various software programmes are being developed and used for specific purposes.

13.4.1 Storing and Retrieval of Information:

Introduction of a computer is not much required for the modern generation, as it is taught to them from their early school-days. Therefore only a brief outline is given here. Main three visible parts of a computer are its monitor (or vision screen, also known as VDU i.e. Visual Display Unit), printer and keyboard. Central Processing Unit (CPU) is its internal part or brain that governs or controls all the work the computer does. Hardware consists of all physical components including monitor, printer, keyboard, CPU and everything else that can be touched, but not the floppy disks. Software are the instructions (programs) a computer needs to run the hardware i.e. to function as a word processor, data base manager, spreadsheet etc. A floppy disk. Zip, CD and pen drive store computer programs and data and can be read through a floppy or CD drive. Hard disk stores permanent memory until erased .or replaced. Graphics is a display of information in picture form. File is a collection of information stored on a disk. Programming means the process of providing a series of instructions to the CPU to get the desired actions. The main computer functions are input, output, storage and processing. CD writers are used to write a CD.

Information Technology (IT) and microchip have changed the world and accelerated the use of MIS. Silicon is the main element to manufacture microchip. PCB, microchip and microprocessor are working like brain and heart for information. They have reduced the size of document, equipment, stationary and files and are capable of doing many functions automatically.

Computer can store, process, change and print tremendous information. Capacity of storing is day by day increasing. Floppy, Zip, CD, VCD, Pendrive, Server etc. are the examples of progress. Hard disk capacity is also increasing. E-mail and V-mail transforms this stored information very fast. They connect all departments of a factory, all offices of a State or Nation and all countries in the world. Storing and presenting of MIS has become very fast and very easy. Laptop and palmtop are very handy. Handwriting is being replaced by keyboard writing. Correspondence and examination through keyboard have become a part of modern culture. Volumes of books and libraries have been reduced to small CDs.

Here 'retrieval' means taking back, finding or extracting information stored in a computer. Any information can be directly fed to the CPU or it can be copied by inserting floppy, CD or pendrive or through an internet. Such information stored in CPU can be recovered by a floppy or CD drive. Such information can also be modified, corrected, altered or added. Thus computer is useful in retrieving many information as per requirement. It saves too much time, labour and volume of work.

13.4.2 Computer Application and Use:

Use of computers for safety and health information systems became critical from 1.970s with the inception of Occupational Safety and Health Act in USA as much documentation, reporting and analysis were required by that Act. In our country, still it is in process.

Manifold use of computers for safety, health and environment is as under :

1. As its general use in science and engineering, computers are used for mathematical and statistical calculations, graphics, documentation, typing, printing, indexing, searching for literature, data

reduction, recording and maintenance of data, control of automated production lines (CAD, Computer Aided Design, CAM, Computer Aided Manufacturing and DCS process control) etc.

2. Automation of information paths and use of Safety Internet System.

3. Process control in plants and laboratories.

4. Accident and medical records.

5. Costing of accidents and losses.

6. Causation analysis of accidents or hazardous events.

7. Signal analysis and medical decision making, e.g. ECG analysis and diagnosis of heart problems, sonography, scanning, surgery etc.

8. Preventive Medicine and Epidemiology, screening, examinations of ill population and comparison of their data with the healthy population for early diagnosis of diseases.

9. Maintaining a long-time qualitative and quantitative record of chemical exposures to workers.

10. Maintaining environmental sampling and measurement data. Using for gas dispersion models and mathematical models for reliability engineering.

11. Preparing and maintaining periodical statements of accidents, injuries, causation wise break-ups, compensation and other costing, firstaid cases, nearmiss cases, safety training, status of compliance etc.

12. Safety reports, manuals, procedures, audit points, mutual aid systems and emergency plan items can be quickly stored, updated and reproduced.

13. Maintaining information of workplace conditions, engineering controls, fire and gas leak controls, administrative controls, medical controls, personal protective equipment and their selection, training programmes etc.

14. Maintaining employee demographics and job histories.

15. Scheduling of inspections, surveys, meetings, workplace monitoring, biological monitoring, condition monitoring, corrosion monitoring, maintenance programmes etc.

16. Reporting at any time to internal management or external statutory authorities or private agencies.

17. Keeping records of Material Safety Data. Sheets, Indian Standards, Statutory Provisions and Forms, Reports for Pollution Control Boards etc.

18. Statistical analysis by using ready-made or self-designed software.

19. Using robots, auto-controls and safety-devices to avoid accidents to persons and property.

20. Simulations to determine where hazards reductions would be more effective and the change in failure probability that would result. Useful to carry out hazard analyses, fault-tree analysis etc.

The special use of computers in addition to general benefits of software (Expertise, Up-to-date information and Improved management) is for Accident recording and analysis. Information on chemical hazards. Audit recording and analysis etc. Data on such points are as under:

1. Automatic printing of statutory and other safety forms.

2. Automatic generation of periodical reports.

3. Analysis of near misses in the same details as injury accidents.

4. Multiple records of injury, property and vehicle damage from the same incident

5. Linked incident costing so that reports can automatically include details of the costs involved.

6. Automatic summaries and their graphical displays.

7. On-line computing using own computer to contact the library or publisher's computer to obtain and read off the information required.

8. CD-ROM (Compact Disc - Read Only Memory) and player for the computer and special software on chemical hazards and control technology. The information from the disc is displayed on the computer screen. Conversely, information in the computer can be copied on CD by using CD writer.

9. Use of floppy-discs, CDs and Pendrive to read off the information.

10. Database from CAMEO, COSHH, APELL etc. and onsite and offsite emergency plans (see Chapter-2 for definitions).

11. Safety audit and environmental audit details by using a set of audit questions (also known as audit protocol). Such audit software packages include:

    a) The ability to edit the audit questions and add audit questions as new risks are identified.

    b) The ability to add guidance for the auditors to specific questions, including details of any relevant standards.

    c) Displaying two or more sets of audit results on the screen at a time and to compare them.

    d) Graphical display of audit summaries.

    e) Automatic generation of audit reports, including action plans.

    f) Diary facilities to assist in managing an audit schedule and keeping track of recommendations for remedial action.

13.4.3 Advantages and Disadvantages of Computerized System

Advantages of computerised information systems are -

1. Ready availability of data and ready reproduction (printed copy) of the stored data.
2. Elimination of monotonous or exhaustive manual labour.
3. No need to keep duplicate records (copies). Reducing files and their storing space. A shared information can be seen at many places (i.e. in different department, conference hall etc.).
4. Improved communication with neat, clean and correct copies. Electronic mail systems can facilitate communication within and between facilities and within short time.
5. Data standardisation and accuracy.
6. Improved analytical capabilities. Analyses not manually practical, can be easily done by a computer. Graphs and Chartes also available.
7. Cost savings by increasing employee productivity, decreasing manpower etc.

Disadvantages (limitations) of computerised nation systems are

1. According to circumstances, need of computers is not always justified. Sometimes it may be premature or totally unjustified on economic grounds.
2. Computers' limitations should be understood. They are not designed for automatic information generation or processing. An operator is required to make data-entry or supply basic information (programme) to computers and his error can give wrong or incomplete information or sometimes erase it and manual search becomes necessary. Mistakes can become repetitive if not corrected in time.
3. Computers can suggest references to documents. They cannot eliminate the need to go through these documents to locate the required information.

4. A typical virus can wash out all information stored in the computer. Then retrieval or restoration of data becomes necessary.
5. Manpower reduction for unemployement.

13.4.4 Hazards and Controls of Working on Computer:

Following hazards have been reported:

1. Ergonomic problems may arise with computer operators. Computer room should not be too noisy, too warm, too cold, unpleasant, humid, congested or poorly lighted. Wrongly designed furniture and sitting arrangement can cause pain in neck and back.

2. Radiation from screen (VDU) and bad contrast can cause eye fatigue and headache. Antiglare ' screen or auto glare (strain) removal device is useful.

3. Psychological problems like monotonous work in isolated position, waiting times, intense concentration (e.g. traffic control) may also arise. Good design and layout of computer room, equipment, fire protection system, records protection, utilities protection and safe storage practices are necessary.

4. A study report of Devis School of Medicine, California, USA, says that pain in waist, shoulders and neck, tension on eyes and legs pain due to decreased blood-circulation are all ill effects of constantly sitting on key-boards. Long sitting in particular posture is hazardous to health. Ergonomic design of sitting and working arrangement and training to computer operator are essential to reduce such pains (News 11-1-2000).

5. It is also reported that using a computer mouse for a long time exposes some people to carpal tunnel pressure levels that may lead to repetitive strain injury to the wrist and hand. This was said by David Rampel, Director of the Ergonomics Program at UC San Francisco (News, Bridges, COEH, June 2000).

6. It is reported that increasing use of computers will develop cataract at younger age and in the year 2050, most of the people will be able to read on computer only after laser surgery (News 23-8-2000).

7. One study report in California revealed that the women working more than 20 hours in a week on video display unit have 80% more chances of abortion than those not working in this way.

8. Another survey in western countries states that 10 to 15% employees working on computers daily complain of body pain and eye strain. Other 40 to 50% employees complain occasionally.
   As per one Japanese study, eye flickering reduces to 7/min. from normal level of 22/min. Eye watering, burning, temporary dimness or vision lose, to see double things etc. are known as computer vision syndrome (CVS).
9. Indian people are habituated to work in 27°C temperature. If they are compelled to work in 17 to 23°C temp, (VDT operators), their health is adversely affected.

Control Measures:

Ergonomists suggest many remedial measures to reduce 'computer-trauma' and other health effects. Some of them are as under:

1. **Computer Vision Syndrome (CVS) -** Eye strain is mainly due to monochromic light or burden of glare (excessive light) on eye. Pain in neck or back is caused due to improper seating of monitor from our face. Monitor should be kept at 10 to 15° below the angle of eye level and 20 to 28 inch away from the face. There should be a balance between monitor light and room light. In darkness, computer should not be operated. Eyes should be turned aside and closed for a few

seconds at the interval of half an hour. A vision guard programme is available to remind this relaxation exercise. It should be loaded in the computer.

2. Hand below the elbow should remain parallel on computer-table, and fingers on key-board.
3. Table and chair should be fully flexible so as to rearrange as requirement. Specially designed back rest necessary.
4. VDU should be so placed that the sight will fall on the correct place on the screen. Computer screen should remain below the eyes so that the eyes and neck are not unnecessarily raised.
5. Key-board should be thin, easy to operate and move and separate from the display unit..
6. Noise from printer should not be more than 55 dB, otherwise hood is required.
7. Operators having sitting work and standing work should be interchanged by job rotation. This will relax the contracted muscles and maintain the body tone-up.
8. Eyes should be examined by Ophthalmologist for internal defects if any. After the age of 40, spectacles become necessary to see from a short distance. Considering the length between the eyes and the computer screen, the special spectacles (not bi-focal) should be worn while working on computer.
9. Lighting, shining and colour have also some effects. They should not be excessive.
10. At every 15, to 30 minutes, eyes should be turned away from the screen to see aside or take rest raise-or move hands, press fingers etc. Legs should be freed from one position. They should have rest support.
11. Working hours on computer should be reduced with increasing age or difficulty.

13.4.5 Causes of MIS failure:

They are of the following types :

1. Insufficient, incorrect or ambiguous information.
2. No two-way communication.
3. Confused reporting.
4. Poor exchange of information.
5. Poor system of communication.
6. Insufficient employee involvement.
7. Untrained employees.
8. No system of feedback receiving for the improvement of MIS.
9. No advanced planning to meet and control emergencies.
10. No advance planning for protection of MIS, e.g. Steps to prevent virus in computers.

Such causes should be detected and removed as early as possible.

13.4.6 Status and Future Goals of Computer Utilization in SHE Services:

Status of computer utilization is being increased and spreading very fast. Today we are rapidly entering in the age of information technology, information highways, internet systems, super-computers to design, scan, develop, store, exchange and transmit data for many complex systems and for many purposes. Paper files and record rooms are all shortened and it seems that in every walk of life computer has to" play some role. Safety, health and environment being the vital subject, cannot remain without the use of computers. Process technology, instrument and control devices, hazard control technology, emergency planning including training, education and information to workers, public, management and Government ... everywhere use of computers is being increased.

One earlier software for SHE services is CAMEO i.e. Computer Aided Management of Emergency Operations. It is a Computer Software Package developed by the Environment Protection Agency (EPA) of USA. The CAMEO software is made operational and available from the National Safety Council, Mumbai. It was explained with the APELL/ CEP workshops at Manali, Mumbai, Kanpur, Cochin, Haldia and Vadodara during 1992 to 1995.

CAMEO gives emergency planner, first responder (fire brigade, police etc.) or safety professional vital information to help handle chemical accidents safely.

What does CAMEO provide :

CAMEO provides tools to help address issues, including

1. Response information for over 4000 chemicals commonly transported.
2. Database templates to help manage chemical inventory information.
3. A mapping capability that allows to identify the proximity and potential hazard posed by facilities to sensitive populations.
4. The ability to create scenario using hazard analysis calculations to assist .in emergency planning and overlay the estimated vulnerable zone on maps.
5. A drawing capability to pinpoint locations of chemicals stored in-community or facility floor plans that are created.
6. An air dispersion model that can be used to help evaluate spill scenarios and evacuation options for 700 airborne toxic chemicals (this features is available for the Macintosh and is being developed for CAMEO DOS).

For other Software, see Part 4.3(c) of Chapter-19.

13.4.7 Integration between Departmental MIS:

Because of wide use of computer software for many purposes, use of internal and external e-mail and information transfer systems, transferring presentation from any computer to the computer of conference room or auditorium, using stored or communicated information for design, production, sale, purchase, taxation, audit, assessment etc, good and effective integration of MIS between all departments is essential and constantly-required.

Information on safety management system, SOP, PPE, safety work permits, statutory and other safety provisions, forms and annexure, training subjects and schedules, safety Suggestions, compliance etc is required by many departments from safety department. Similarly safety department needs feedback and other information from other departments. This is not possible without effective integration of MIS between all departments.

Therefore continuous integration between departmental MIS should be maintained and updated.

EXERCISE

1. Comment on the following Statements by giving your opinion:

1. Accident problem is not a big problem. Adequate and sufficient data are available.
2. Accident cost to the injured person is not much. He is insured and therefore no need to worry.
3. Indirect cost of accident is less than the direct cost.

4. Indirect costs of accident are not visible and not important.
5. Preventive' costs may be less than the total costs of accidents.
6. Management should realize the costs of accidents to improve productivity.
7. Cost calculation of accident is not difficult. Its record can be maintained and well utilized.
8. How to fix 'man-days lost' for death of a worker, is a problem. No figure is fixed for that
9. If frequency rate is reduced, severity rate will also be reduced.
10. 'Reportable lost time injury' is more important than lost time injury' for the purpose of safety.
11. DH and FSI are same. DH denotes degree of improvement.
12. Safety activity rate takes four things into consideration..
13. A serious accident causes much effect on severity rate but little effect on frequency rate.
14. Frequency rate can be used to compare present safety performance with the past.
15. Take care of frequency rate, then the severity rate will take care of itself.
16. Frequency rate is a better base of comparing two or more units than the severity rate.
17. No 'injury rate' is capable of giving complete picture of safety performance.
18. Injury rates also represent properly damage and time losses.
19. Injury rates have drawbacks..
20. 'Man-hours worked' taken from 'Attendance Register' do not give correct picture.
21. 'Severity rate' does not represent of severity of pain and suffering of a worker.
22. There is no need to prepare a 'Safety Budget' separately. General budget can take care of it.
23. Safety budget has many items to include.
24. Safety performance rates should be considered while preparing a safety budget.
25. It is difficult to up date labour statistics.
26. Year-wise fatal and nonfatal injuries are useful to know safety-status.
27. Cause-wise injury figures have meaningful message.
28. Incidence rate and Frequency rate both are useful for comparing 'status' in safety performance.
29. Four types of information are generally required for safety.
30. Computerised information system has many advantages.
31. Computerised information system has some limitations also.
32. There is no hazard in working on computers.
33. Ill effects of constantly sitting on keyboards are many.
34. Ergonomic measures to reduce 'computer trauma' are important.
35. MIS cannot fail.

2. **Write Short Note OR Explain in brief:**

1. Need of statistics of safety.
2. Magnitude of the safety problem.
3. Inadequacy of safety data.
4. Accident cost to the injured person and his family.
5. Direct and indirect costs of accident.
6. Frank E Bird's Iceberg concept of indirect costs.
7. Factors of Hidden Costs.
8. Accident cost to the society.
9. Limitation of Accident Cost Data.
10. Utility of Accident Cost Data.
11. Utility of Safety Performance Rates.
12. Significance of Injury Rates.
13. Drawbacks of Injury Rates.
14. Benchmarking for safety performance.
15. Items of Safety Budget.
16. Use of computers for safety information.
17. Hazards of working on computers.

18. Computer trauma and remedial measures.
19. Causes of MIS failure.
20. Future goals of computer utilization in SHE services.

3. Explain or Discuss with details :

1. Why do we need safety statistics? How is it useful?
2. Who do suffer the costs of accidents? In what way? And of what types?
3. Explain Heinrich's list of indirect costs of accident.
4. As a Safety Officer, design an Accident Investigation Form with necessary contents.
5. Explain various types of 'injuries' under IS:3786, or the WC Act or ESI Act.
6. Explain how injury rates are useful and what are their limitation.
7. Explain the purpose and procedure of safety budget.
8. Explain the process of Compilation, Collation and Analysis of safety Information.
9. Explain modern methods of programming.
10. Explain manifold use of computers for SHI services.
11. Discuss advantages and disadvantages of computerised information system.
12. Discuss hazards of working on computer; and state their remedial measures.
13. What information is supplied by CAMEC software?
14. How can we integrate MIS between different departments?
15. What future do you foresee of computer utilization for SHE services ?

Reference and Recommended Reading

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10. Industrial Hazard and Safety Handbook, R.W. King and John Magid.
11. Accident Prevention Manual for Industrial Operations, National Safety Council, USA.
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18. Safety Metrics : Tools and Techniques for Measuring Safety Performance by Christophe A. Janicak.
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20. Visual display units : Job contant and stress in office work by Fe Josefina F. Dy. by ILO
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CHAPTER – 6

Safety Management

THEME

Before proceeding toward safety management, it is necessary to know about the general management.

1. THE CONCEPT OF MANAGEMENT

The concept of management has to origins Indian and Foreign.

1.1 An Indian Origin

Before considering the modern concept of management, it is interesting to know our ancient concept of management.

Oldest Indian concept is that the God is the Supreme Manager who manages this universe. He is the creator, protector and killer. These managerial functions are done by Brahma, Vishnu & Mahesh. He plans, creates, controls, directs; governs, organises, evaluates, motivates, communicates and co-ordinates all activities. He is the King of kings, the Great Administrator and the Manager. We still believe this.

Then with the rise of jktk (King), jkT;O;oLFkk (State Affairs or Ruling) and U;k;O;oLFkk (Law & Justice) for iztk (Public), our old management ideology moved and developed around King, Kingdom and his administration. The words jkT;/keZ] iztk/keZ and /keZ were giving and still giving many duties for better management.

Ramayana, Mahabharat and Kautilya's Arthshashtra describe elaborately ancient concepts of management. Some citations are given below :

vHkkoks ok izHkkoks ok ;=k ukLR;FkZdke;ks% A
lekts LokRe:iRrokr~ /keZpdz izorZue~ AA

Where wealth and desires are neither absent or dominating, by its own, Dharmachakra i.e. the best and dynamic management prevails in the society.

The Rugved states:

Lekuks ea=% lfefr% lekrh lekua ozre~

We should move by one common inspiration, come to a common decision and accept common rules and regulations.

Raja was the guardian of the social constitution. It is said

o.kkZJe/keZizfrikydks jktk A

Raja was the executor and protector of all sections of people and their /kkfeZd ways of life. (The word king or monarch is not a real synonym of Raja as the word 'religion' is not the synonym of /keZ).

How was the concept of self-management ?

u jkT;a uSo jktk·lhr
u n.M;ks u p nkf.Md % A

/kesZ.kSo iztk losZ
j{kfUr Le ijLije~ AA

There was neither the State nor the State Officials, neither the punishable nor those authorised to punish. The people used to protect each other only on the strength of Dharma.

But such ideal condition did not last longer and gradually the administration of the State and Raja were immerged in the society. Then Raja started administration, planning and management.

lHkk or 'assembly' was defined by Janak as under

u lk lHkk ;RFk u lfUr lUrks A
u rs lUrks ;s u Hk.kfUr /keZe~ AA
jkxa p nks"ka p igk; eksga A
/keZe~ Hk.kUrk p HkofUr lUrks AA

Unless any assembly is attended by a few exponents of Dharma, those who are detached in mind, are faultless in expression and action and have no allurements, the same cannot be said as properly constituted or held. This describes the qualitative quorum for assembly. Such assembly will manage the best. The deep wisdom of this constitutional provision is unchallengeable.

jktk Hofr Hkwrkuka fo'okL;ks fgeokfuo A % 'kkafrioZ

In every respect of public policy, the State should be worthy of reliance of people. Such are the managerial functions of the State as conceived by Indian thinkers of old age. (thousands years BC).

The whole trend of Ashram Dharma was based on non material pursuits of life and the management by minimum (MBM).

;kon~ fHkz;sr~ tBja rkon~ LoRroa fg nsfguke~ A
vf/kda ;ks·fHkeU;sr l Lrsuks n.MegZfr AA

So far one takes as per requirement of his stomach, it is his own. He who takes more than this, is the thief and liable for .punishment.

The managers (leaders of the society) are advised by Gita:

;n~ ;n~ vkpjfr Js"B % rRrnsosrjks tuk% A
l ;Rizek.ka dq:rs yksdLrnuqorZrs AA

The behaviour of the top men is followed by others. What he establishes, people follow it. This is the true method of inculcating discipline - the influence of a high ideal and example at the top level (management).

Kautilya Chanakya is the great father of Indian Administration and Management for State Affairs of his age. He says:

Izktklq[ks lq[ka jkt% iztkuka p fgrs fgre~ A
ukRekfiz; fgra jkK% iztkuka rq fiz;a fgre~ AA

In the happiness of public, lies the happiness of the Ruler (Raja). In the interest of public, lies the interest of him. It is in his interest to carry out such functions which are liked by the people and not merely by him (Example of Shri Ram).

Various management, administrative and executive functions are well defined by **Kautilya** in his Arthashashtra (Rajniti). Management of education, ministers, detectives, ambassadors. State Officials, mines, horse stable, weapons, weights and measure, income and revenue, agriculture, places for execution of death sentence, transport and vehicles, tank (Ratha), military, the Chief of Army and their functions, currency, citizens, agreements, marriage, heritage, house building, sale of property, disputes, loan, servants and labour, partnership, exchange, aggression, gambling, protection of people, theft, fine and punishment, welfare, duties of public servants, implementation, peace, industry, king, rules of friendship, war, treatises, behaviour with enemies, habits, power, weakness, situation, loss and profit, methods of defence, types of war and policies, experiment, other policies, establishment of peace etc. are described in details.

No such document was existing in the world in 'Kautilya's times (some 2500 years ago). This is his wonderful and singlehanded unique contribution on so many subjects •of management.

1.2 The foreign origin :

Since human beings started living in groups and families in ancient time, some thoughts of leadership and management were evolved from the beginning.

Egyptian papyri recognised the importance of organisation and administration in the bureaucratic states of antiquity long back in 1300 BC

Confucius, in ancient China suggested public administration and admonitions to choose honest, unselfish and capable public officers.

The Athenian commonwealth in early Greece .indicates managerial function for councils, courts, officials and board of generals. Socrates' definition of management as a skill separate from technical knowledge and experience is close to current understanding of the function.

The existence of the Roman magistrates with their functional areas of authority and degrees of importance, indicates characteristics of organisation.

The Sumerian civilisation had a system of tax collection in 300 BC

The Roman Catholic Church, the Pyramids of Egypt, the cameralists (German and Austrian public administrators in 16th to 18th century), the Chinese Civil Service and old military organisations of earlier centuries present some forms of the old foreign concept of management and administration.

See Part 5.1 of Chapter-1 also.

2. EVOLUTION OF MANAGEMENT THOUGHTS AND PRINCIPLES

Management thoughts are of two types - Old and Modern. They are discussed below.

2.1 Old Management Thoughts and Principles:

As stated in Part I, our Vedas, Rushies and Kautilya are the pioneering contributors to the origin of management thoughts of their time.

Some foreign contributors and their thoughts are given below.

	Contributor	Thoughts
1.	Robert Owen (1771-1858)	Human resources are more important than machines. He started on' human relations and suggested shorter working hours, rest intervals, training of workers in hygiene, canteen, children education, housing facilities etc. He is known as the father of personal management and co-operation.
2.	Charles Babbage (1791-1871)	Use of science and mathematics to factory operations. Division of work. Applicability of time & motion study. Cost reduction by improved methods. Participative decision making. Specialisation. Work measurement and optimum use of machines.
3.	Henry Varnum Poor	During 1849 to 1862 he watched the American railroad system and suggested three principles for managers- organisation, communication and information. He suggested 'Managerial System' of accountability, summarising costs, revenues and rates, leadership and feeling of unity.
4.	Henry Robinson Towne (1844-1924)	He urged the combination of engineers and economists as industrial managers, exchange of experience among managers and art of workshop management.
5.	James Watt and Mathew Robinson Boulton (1796-1848	Market research and forecasting standardisation of components and parts, production planning, planned machine for better workflow, statistical record advance control reports and cc accounting procedure, employ sickness benefit scheme and scheme for developing executive.
6.	Henry Metcalfe (1847-1917)	Record of observations & experiences for cost estimates. System of time cards and material cards to inform the management good work of the workers. H system of management was put record by the America Management Association.

Thoughts on Scientific Management:

- F.W. Taylor, Henri Fayol and subsequent thinkers developed the thoughts of Scientific Management since the beginning of 20th century.

F.W. Taylor (1856 - 1915) : Frederick W. Taylor is called the founder of modern scientific management. His famous work 'The Principles of Scientific Management' was published in 1911. His main concern was with achieving efficiency of human beings and machines through time and motion study. He suggested following functions for managers :

1. Replacing rule-of-thumb methods with scientific determination of each element of a man's job.
2. Scientific selection and training of workmen.
3. Co-operation of management and labour to accomplish work in accordance with scientific method, and
4. A more equal division of responsibility between managers and workers, with managers planning and organising the work.

Henri Fayol (1824 - 1925) : Henri Fayol the French industrialist published his acute observations on the principles of general management in 1916 in French and divided all activities of industrial undertaking into six groups :

1. Technical (manufacturing or production).
2. Commercial (buying, selling and exchange).
3. Financial (search for and optimum use of capital).
4. Security (protection of property and persons).
5. Accounting (including statistics) and
6. Managerial (planning, organisation, command, co-ordination and control)

Fayol identified five elements or functions of management process as under -

1. Planning to foresee and provide means for the future
2. Organising to provide a business everything useful to its functioning e.g. raw materials, tool capital and personnel
3. Commanding to maintain activity among personnel
4. Co-ordinating to unify and harmonise all activities and efforts
5. Controlling to see that everything occurs in conformity with established rules and expressed command

Fayol published his book 'Administration Industrielle et Generale' in 1916. It was also published in English in 1949 under the title ''General and Industrial Management'.

Fayol gave ‘General Principal of Management’ as -

1. Division of work.
2. Authority and responsibility.
3. Discipline.
4. Unity of command.
5. Unity of direction.
6. Subordination of individual to general interest.
7. Remuneration of personnel.
8. Centralisation.
9. Scalar chain.
10. Order.
11. Principle of equity.
12. Stability of tenure of personnel.
13. Initiative and
14. Esprit de Corps i.e. unity of effort through harmony of interests.

Fayol advocated the universality of management concepts and principles. He said that managerial functions and principles are applicable to all types of organisations.

Mary Parker Follett (1868 - 1933) : She analysed the problems of power, authority, conflict and control from a psychological viewpoint and revealed the operation of social process and group dynamics in industrial organisation. She contributed in the areas of motivation, leadership, authority and co-ordination and recognised management as a profession.

Her management thoughts can be summarised as (1) Constructive conflict (2) Laws of the situation (3) Leadership (4) Authority & Responsibility (5) Principles of Co-ordination.

George Eiton Mayo (1880 - 1949) : His thoughts concluded from his 'Hawthorne experiments', put stress on human and social factors in industry and called the 'Father of Human Relations Approach to Management'. He said that influence of inter-personal relations, attitudes of supervisors and other social and psychological factors is more than' the influence of working conditions. Worker respond to total work situation including their care, recognition, participation, work design etc.

Chester I. Barnard (1886- 1961) : His thought can be summarised as -

1. Concept of organisation.
2. Formal and informal organisations and interaction between them.
3. Elements of organisation with the systems of fictionalisation, incentive, authority and logical decision-making.
4. Functions of the executive.
5. Motivation.
6. Organisational equilibrium and
7. Executive effectiveness.

He is regarded as the spiritual father of the social system school. He stressed upon leadership, motivation, informal organisation, status, acceptance of authority and communication.

Herbert A. Simon : He was an American political and social scientist (1978). His thoughts were focused on -

1. Concept of organisation.
2. Decision-making.
3. Bounded rationality.
4. Administrative man.
5. Communication and
6. Influence.

Rensis Likert (1903 - 1972) : He was a leading social psychologist. He classified 'management styles' in four categories - Exploitative autocratic. Benevolent autocratic, Participative and Democratic. He developed the concept of linking pin' to integrate individual and organisational goals. He and his associates also developed a measuring instrument (scale) to evaluate leadership styles of managers.

Douglas McCregor (1906 -1964): He is known for his theory of motivation (theory X and theory Y). He stressed on human relations and 'satisfied and happy employees' as an objective of organisation.

See Part 8.3.7 of Chapter 3.

Chris Argyris : His books on management were published between 1959 to 1971. He is known for his immaturity-maturity model of personality. He told that employees must be given responsibility, authority and increased control over the decision-making to improve their work environment.

Peter F. Drucker : He was a leading management consultant and a prolific writer. Born in 1909, was a leading proponent of managerism. He has written 20 books on different facets of management He considers management as the dynamic, life giving element in an organisation. His writings are landmarks in management. He has exercised major influence on contemporary management thought and practice. His thoughts in brief are as under -

1. Nature of management -it is a 'practice' rather than profession.
2. Managerial functions - To manage managers, workers and the work.
3. Organizational structure.

4. Decentralization.
5. Management by objectives (MBO) - Philosophy resting on human action, behaviour and motivation. He suggests 8 key areas in which clear objectives must be laid down - market, innovation, productivity, physical and financial resources, profitability, managerial performance and development, worker performance and attitude and public responsibility.
6. Futurity - He was worried by rapid progress of technology and its impact on society.

H. W. Heinrich : He is called the father of 'safety management'. His famous book'- Industrial accident prevention - A Safety Management Approach' was first published in 1931. He is famous for his accident causation theory and five fundamentals of accident prevention. He has explained safety functions for supervisors and managers. See Part 7.1 and 8.2 of Chapter-4.

2.2 Modern Management Thoughts (Recent Trends) :

Development in technology, science, trade, business and employment have increased the size and complexity of management and organisation. Quality standards, consumers awareness' after sale-service, mass production, automation, human resource development, stress on training, trade union demands and use of computer based programmes are adding new trends in management. Public and private both the sectors have increased. Challenges and manifold responsibilities are increased demanding technocrat role of the managers and demand for MBA study is also increasing.

Areas of such modern trends are

1. Information technology.
2. Electronic Communication - advanced computers, FAX. Email. Internets.
3. Importance of human relations.
4. Challenges by trade-unions.
5. Impact of Government policy.
6. Facing Government authorities (intervention).
7. Marketing.
8. Publicity.
9. Competition.
10. Leadership.
11. Futurology.
12. Flexible Organisation.
13. Changing situations and decisions.
14. Variety of goals.
15. Professionalism i.e. increasing studies of management subjects.

New developments, systems and approaches in all above areas, provide Modern Management Thoughts (new trends). Thus, the management thoughts are changing and depending on modern trends.

3. DEFINITIONS, NATURE AND IMPORTANCE OF MANAGEMENT:

Definitions on management are available as under:

1. The accomplishment of desired objectives by establishing an environment favourable to performance by people operating in organised groups.

2. It includes the managerial functions of - (1) Establishment of objectives and (2) Process of planning, organising, controlling and directing i.e. motivating and co-ordinating to attain those objectives and innovating to improve the objectives for the future -**Rustom S. Davar.**

3. It is a multi-purpose organ that manages a business and manages managers and manages worker and work-**Peter Drucker.**

4. It is the art of getting things done through people - **Lawrence.**

5. It is the art of getting things done through and with people in' formally organised groups **Harold Koontz**.

6. The task of creating the internal environment for organised efforts to accomplish group goals. In co-ordinating group activity, the manager plans, organises, staffs, directs and controls.

7. The function of executive leadership anywhere **- Ralf C. Davis.**
8. Management is a distinct process dealing with group activity.

9. The objectives are achieved through establishing salient relationships between human and nonhuman resources.

10. The manager does not necessarily perform things for himself, but, accomplishes objectives through others in the group situation.

11. It is the art and science of decision making and leadership - **D.J. Clough.**

12. It is an art of knowing exactly what you want men to do and seeing that they do it in the best and cheapest way - **F.W. Taylor.**

13. To manage is to forecast and plan, to organise, to command, to co-ordinate and to control **Henri Fayol.**

14. Management is the coordination of all resources through the process of planning, organising, directing and controlling in order to attain stated goals - **Henry L. Sisk.**

15. Management is a social process entailing responsibility for the effective planning and regulation of the operations of an enterprise **E.F.L. Brech.**

16. Management consists of all organisational activities that involve goal formation and accomplishment, performance appraisal and the development of an operating philosophy that ensures the organisation's survival within the social system - **W.J. Duncan**.

17. Management is the creation and maintenance of an internal environment in an enterprise where individuals, working in groups, cart perform efficiently and effectively toward the attainment of group goals - **Koontz and O'Donnell.**

18. Management is a distinct process consisting of planning, organising, actuating and controlling, performed to determine and accomplish the objectives by the use of people and resources **George R. Terry.**

19. It may be defined as a technique by means of which the purposes and objectives of a particular human group are determined, clarified and effectuated - **Peterson and Plowman.**

20. It may be defined as the art of securing the maximum results with the minimum of effort so as to secure maximum prosperity and happiness for both the employer and the employee and give the public the best possible service - **John F. Mee.**

21. Management is simply the process of decisionmaking and control over the action of human, beings for the express purpose of attaining 'predetermined goals - **Stanley Vance.**

Nature (Characteristics) of Management :

1 **It is a group of people and function both :** Management is a group of people with different levels depending on responsibility and it is a group of functions (process elements) like planning, organising, staffing, directing, controlling, reporting, budgeting, motivating, coordinating etc.

2 **It is universal :** Whether it be a family, office, club, army, school, trade, industry or business, management is required every-where.- t*s fundamental principles are applicable in all areas of organised activity.

3. **It is an Art & Science both :** As it requires knowledge, skill, creativity etc., it is an art. As it requires universal application of principles for definite results and systematic knowledge, mathematics and use of scientific rules or study, it is a science also.

4. **It is an executive function :** It is a technique by which the objectives are predetermined and obtained by methods required.

5. **It is purposeful :** Management without objectives is meaningless. It is creative, decides goals and try to achieve them. Therefore, it is purposeful.

6. **It is dynamic :** because it changes with time, need, objectives and challenges of business to be successful at all times. It cannot be static.

7. **It is intangible :** because the process of management is invisible though the managers are visible.

8. **It is leadership :** Manager acts as a leader of the groups, creates environment for followers and gets work done through them. Therefore, it is a leadership function.

9. **It is decision-making :** All managers have to take decisions with utmost care using data and analysis to obtain results. Without decision, management is not possible.

10. **Co-ordination as unifying force :** The essence of management lies in co-ordinating all its efforts into a team. It requires harmony instead of conflicts. It integrates human and other resources.

11. **It is a practice & profession both :** Managers are made and not born. They learn by practice. The whole management process is practice to acquire goals. Only after training, skill and experience, it can become a profession like management consultancy.

12. **It is a social process :** Management is by people, through people and for people. Human factor is most important. After all everything is for human beings. Therefore, it is a social process.

13. **It is situational or contingency :** because decisions are dependable on situations which are changeable.

14. **It is multidisciplinary :** It derives knowledge from several disciplines like engineering, science, economics, mathematics, psychology, sociology etc.

15. **It is a continuous process :** It is an on-going process continuing to operate till achievement of goals.

16. **It strives for organisational goals :** If there is no management, there may be conflict between individual (personal) goals and organisational goals. Management has to work for organisational goals (objectives).

Importance (Significance) of Management:

1. It is a key to economic success of nations, organisations and all group activities.
2. It accelerates the process of development and cuts its cost.
3. It accelerates capital formation and progress.
4. As Peter Drucker 'says 'Only superior management, competence and continuously improved management performance can keep us progressing, can prevent our becoming smug, self-satisfied and lazy.

4. ELEMENTS OF MANAGEMENT FUNCTIONS

All above criteria conclude seven basic elements or functions of management as follows:

1. Setting up the **objectives** well defined.
2. **Planning** the course of action to be taken to attain above objectives.
3. **Organising** the structure of staff and assigning specific responsibilities to different individuals (members, workers) i.e. delegation and decentralisation of power and authority.
4. **Directing** and **Co-ordinating** the efforts of all members working for the organisation.
5. **Controlling** the activities of the members through setting up standards for performance. It includes monitoring and evaluating that the objectives are achieved and follow up for those to be achieved.
6. **Motivating** the members to cooperate with each other for the achievement of the objectives
7. **Innovating** to improve the objectives for the future.

See Figure 6.1 and 6.2.

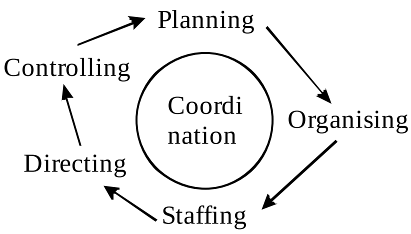

Fig. 6.1 Elements of Management Process

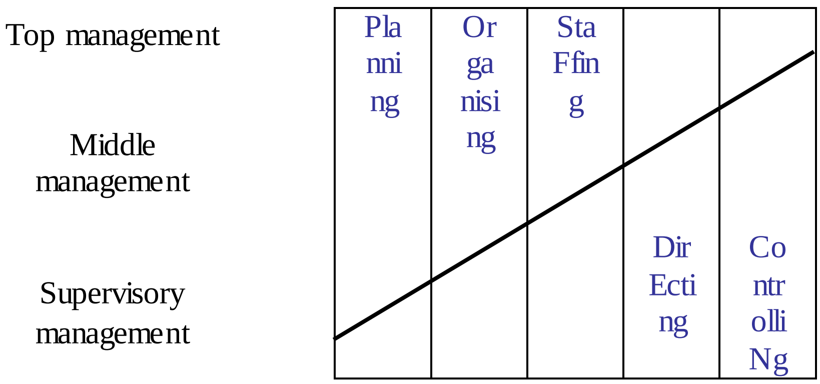

Fig. 6.2 Managerial Functions at different Levels

Fig. 1 Explains inter relationship of basic elements of management process and Fig. 2 shows their proportion at different levels.

The terms management, organisation and administration are used side by side. The term 'administration' is used to refer to the activities at the higher levels of the management, such as Government administration is the higher management for the largest section (people). The term 'organisation' is generally used for the structure of responsibilities and relationship attached to the executive and supervisory posts.

The words **direction, superintendence and supervision** are also used side by side to include determination of objectives and policy and to exercise overall control over the affairs of an enterprise, directing subordinates, motivating and leading them, communicating, getting employees to accomplish and overseeing their tasks.

Administration is that part of the management which lays down the objects, policies, programmes and procedures for which the organisation and its management strive and operate to accomplish the predetermined objectives.

Organisation is that part of the management which lays down the structure of responsibilities to distribute activities or functions among the managerial, supervisory and specialist personnel and the interrelationship among them.

Thus, administration can be said 'brain' or 'mind' and its function is 'thinking'. The organisation is 'head' and 'body' and its function is 'doing'. The management is 'eyes' and its function is 'seeing' that the things are done (by the organisation) as thought (by the administration). All the three are the organs of one body or entity.

Management are of many types such as factory management, business management, safety management, materials management, project management etc.

The materials management is defined as the function responsible for the co-ordination of planning, sourcing, purchasing, moving, storing and controlling materials in anoptimum manner so as to provide a pre-decided service to the customer at a minimum cost

5. MANAGEMENT PRINCIPLES

5.1 General Principles of Management:

According to Joseph L.Massie, general principles are 'approximations of generalisations from experience'. These principles are short statements for guidance and practice and not the rules or regulations. They are not rigid. They may change with change in conditions. They have been developed in course of time and may further develop from new experiences.

According to George Terry 'by means of principles of management, a manager can avoid fundamental mistakes in his job and foretell the results of his actions with confidence'.

According to Harold Koontz, these principles help managers to (i) improve efficiency (ii) increase knowledge (iii) impart training (iv) improve research and (v) attain social goals.

The nature of management principles is characterised by its feature of universality, dynamic, relative and human nature.

Henry Fayol has listed following 14 principles of management:

1. **Division of work** - Work of every person should be limited to a single leading function to do more and better work with the same effort.

2. **Authority and Responsibility** - They go hand in hand. Authority is the right to give orders and power to exact obedience. Responsibility arises when authority is given. Responsibility implies an obligation to perform duty (task) in a satisfactory manner. Official authority is derived from position one holds while personal authority is derived front intelligence, experience and knowledge one holds.

3. **Discipline** - It is the obedience to agreement between members and must prevail throughout an organisation for its smooth functioning. Clear understanding between workers and management regarding their rules, regulations, orders and penalties is necessary.

4. **Unity of Command** - Every employee should receive orders from one superior only. Dual command is a source of conflict or confusion. One group of workers should work under one supervisor only.

5. **Unity of Direction** - There should be one head and one plan for a group of activities having the same objective to ensure unity and co-ordination in management.

6. **Subordination of individual to general interests** - Employee's personal interest should not dominate the general i.e. management's interest. In case of conflict between such interests, personal interests should be sacrificed.

7. **Remuneration of personnel** -The amount and methods of payment should be just, fair and satisfactory to both employees and employers.

8. **Centralisation** - To decrease subordinates' role is centralization and to increase it is decentralisation. This principle should be introduced to yield the best results considering individual circumstances.

9. **Scalar Chain** - Normally a chain of authority runs from the highest authority to the lowest rank, but however if it is very long and causes delay, cross-communication (shortcut) between two employees at lower level should be permitted to avoid such delay (Gang-Plank principle).

10. **Order** - There should be proper arrangement of men and materials in required order. As there should be a place for everything and everything should be in its proper place, there should be an appointed (clear) place for everyone and everyone should be in his/her appointed place. This kind of order requires precise knowledge of human requirements and resources of the concern to maintain balance between them.

11. **Equity** - There should be equality, justice, kindness and impartiality in treatment to employees and a sympathetic and unbiased attitude toward them. This generates better industrial relations.

12. **Stability of tenure of personnel** - Provide job security and long-term service to reduce labour turnover. Instability hampers interest, motivation and efficiency of employees.

13 **Initiative -** This refers to freedom to think and take decision. Employees should be given an opportunity to take initiative to formulate and execute plans even though some mistakes may result. When employees are given freedom to work independently they tend to grow and develop.

14 **Esprit de corps** - Instead of 'divide and rule' management should strive to install team spirit, co-operation and harmony among workers to make the management united and powerful.

These principles are to be practised for safety management also.

5.2 Managerial Role, Authority, Responsibility and Power :

Managerial Roles :

Mintzberg describes following ten roles for managers:

I. Interpersonal Roles:

1 **Figurehead -** acts as head, performs legal and social duties e.g. greets a special visitor, takes customer to lunch/attends ceremony etc.

2 **Leader** - responsible for work unit e.g. hiring, firing, motivating, training, staffing.

3 **Liaison** - maintains outside contacts to get favours, feedback, follow up, information etc. e.g. meeting a peer in another department, contacting Government Official etc.

II. Information Roles :

4 **Monitor** - seeks and receives information on progress, performance, environment etc., e.g. asking reports.

5 **Disseminator -** passes information e.g. gives workers important date, briefs higher executives.

6 **Spokesman -** sends information outside e.g. represents company in meeting, replies on behalf of company.

III. Decisional Roles :

7 **Entrepreneur -** improver of the work unit e.g. looks out for new ideas, develops new programmes.

8 **Disturbance handler** - responds to pressure, crisis etc. e.g. faces strike, decides how to tackle emergency, failure of supply of money, material, services etc.

9 **Resource allocator** - allocates resources of men, money, material, market, machines, methods etc. e.g. sets budget priorities, selects good proposals.

10 **Negotiator** - represents management in settlement, agreement, bargaining, negotiating, hearing grievances and giving opinion etc. e.g. negotiating union demands.

Authority:

Authority means legal or delegated power or right to a person. Government officials have powers vested in them by law and therefore they are called 'Government authorities'. Similarly when a manager is given powers to perform his managerial roles, by the higher executive, board or the owner, it is said that he has authority to act, sign etc. e.g. Safety Officer has authority to design or sign safety work permit or to sign a purchase order of safety equipment.

Authority can be delegated also. It is decentralisation of power downward. A safety officer can delegates his authority to permit some work to safety supervisors.

Authority gives right to a manager, and disobedience of his order injures his right for which a penalty is possible. The statements of authority are called ''authoritative' which may set an example. It has force of implementation.

Definitions :

1. **Henry Fayol -** Authority is the right to give orders and the power to exact obedience.

2. **Koontz and O'Donnell -** Applied to the managerial job, authority is the power to command others to act or not to act in a manner deemed by the possessor of the authority to further enterprise or departmental purpose.

3. **Herbert Simon -** It is the power to make decisions which guide actions of others.

4. **Terry -** Authority is exercised by making decisions and seeing that they are carried out.

Characteristics:

Thus, characteristics of authority are

1. It is attached with position, is legal, legitimate and formal.
2. It gives power to superior i.e. right to act, control, command subordinates and to achieve goals.
3. A subordinate obeys the superior by virtue of his authority.
4. It is not unlimited, its extent and limits are defined in advance.
5. It is a relationship between two individuals - a superior and his subordinate.
6. It is used to achieve organisational (not personal) goals.
7. It is a key to the managerial functions.
8. It gives right of decision making and to get the decisions carried out.
9. It can be delegated.
10. It is objective, though its existence is subjective.

Theory:

Theories for the sources of authority are
1. Formal authority theory.
2. Acceptance authority theory.
3. Competence authority theory.

Scope:

Its scope or limitations are
1. Biological limitations.
2. Physical limitations.

3. Legal constraints.
4. Social constraints.
5. Economic constraints.
6. Limited span.
7. Organisational limitations.

Responsibility:

Authority brings responsibility. When authority is given to a manager, he possesses responsibility i.e. accountability and is answerable for all works, acts and functions for which authority was given to him. When a safety officer is authorised for all safety functions, he becomes responsible i.e. liable to give explanation for the success or failure of all his decisions, works, functions etc. Safety Officer is responsible for accident prevention work. When supervisor allows working on unguarded machine and accident takes place, he is responsible for this work of his omission or negligence. When responsibility is given to us, we must strive to fulfil it by all our sincere efforts and care.

A concept of responsible care' is developed to run our plant with utmost care toward surrounding society. Breach of responsibility attracts penalty.

Definitions :

1. **M. E. Hurely -** Responsibility is duty to which a person is bound by reason of his status or task. Such responsibility implies compliance with directives of the person making initial delegation.

2. **Koontz and O'Donnell -** Responsibility is the obligation of a subordinate to whom duty has been assigned to perform the duty.

3. **R. C. Davis** - Responsibility is the obligation of an individual to perform assigned duties to the best of his ability under the direction of his executive leader.

4. **Dalton McFarland** - Responsibility is the duties and activities assigned to a position or to an executive.

5. **Theo Haimann** - Responsibility is the obligation of a subordinate to perform the duty as required by his superior.

Characteristics:

Main characteristics of responsibility are

1. It cannot exist without authority and vice versa.
2. It originates from superior-subordinate relationship.
3. It is absolute and cannot be delegated. The authority can be delegated.
4. He who holds (accepts) responsibility, is accountable to his superior.
5. It is an obligation of a subordinate to perform the duty assigned to him.
6. It is a derivative of authority.
7. It flows upward while authority flows downward.
8. Accountability arises out of responsibility and they go together. Authority gives responsibility which, in turn, creates accountability.

Power :

Power means ability or capacity to do something, to act, to control, to exercise force or command etc. Power also comes with authority because authority gives right and that right gives power. Powerless person cannot do anything. Manager without power cannot manage things, subordinates do not follow his orders and goals of management can never be achieved. Therefore, power should be vested by giving authority to manager. In case of doubt or ambiguity, powers are to be assumed by the manager to get the work done. Power is to be exercised with due care and reasonable requirement. Undue use of power may create opposition.

A manager's power may be measured in term of his ability to give order or reward, punish individuals, withdraw order or reward etc. Power is an important means to enforce obedience to the rules, regulations and decisions of the organisation. Its use (exercise) may affect the behaviour of people. Distinction between authority and power can be explained as under :

No.	Authority	Power
1	Right to do or command.	Ability to do or command.
2	Derived from position in organisation or institution.	Derived from many sources like authority, seniority, knowledge, competence etc.
3	Flows downward – can be delegated.	Flows in all direction – cannot be delegated.
4	Legitimate – resides in the position.	May be illegitimate, extra constitutional or assumed.
5	Increases as one goes up in hierarchy.	May or may not accompany increase in authority.
6	Right to allocate resources.	Ability to control resources.
7	Narrow term- one source or subset of power.	Broad concept – can achieve result when authority fails.
8	Visible from organisation chart. It is institutionalized power.	Not visible from organisation chart.

Thus, authority, responsibility and power go side by side and are useful tools for managers to achieve the organisational goals.

5.3 Span of Management :

The span of management refers to the number of subordinates a manager or supervisor can supervise effectively because of his limitations of time, capacity, ability, nature of work, pressure of work etc. No single individual can effectively supervise unlimited number of subordinates. The terms span of management, span of control, span of supervision, span of authority are used interchangeably in management literature.

V.A. Graicunas, a French management consultant has given following formulae for different relationships due to span as under : Direct single relationships = n

(n = No. of subordinates)

Direct group relationships = $n (2_n / 2-1)$
Cross relationships = $n (n- 1)$
Total relationships = $2_n/2\ n (\quad +n-1)$

This formula gives some figures as under :

No. of Subordinates	Total Relationships

1	1
2	6
3	18
4	44
5	100
10	5210
18	2359602

Black and Scott have given another formula as $S = L\sqrt{n}$ where S = Span of Control, L = No. of Supervisory levels and n = No. of Employees.

Thus, if there are 125 employees and 3 levels of supervision, average span of control would be :

$$S = 3\sqrt{125} = 5$$

This is an average (general) indicator and it ignores details. Care is required in interpretation.

Modern approach discards such magic formulae and contends that span is flexible and there is no single (fixed) span for all situations. It depends on many factors as under :-

Factors determining Span of Management :

They are

1. Nature of work.
2. Type of technology.
3. Ability of the manager.
4. Capacity of subordinates.
5. Degree of decentralisation.
6. Planning.
7. Staff assistance.
8. Communication techniques.
9. Time available for supervisors and
10. Geographical distance of subordinates.

Narrow (tall) & Wide (flat) Span :

Narrow span means a few subordinates and wide span means more subordinates directly under one manager or supervisor. See Fig 6.3 & 6.4.

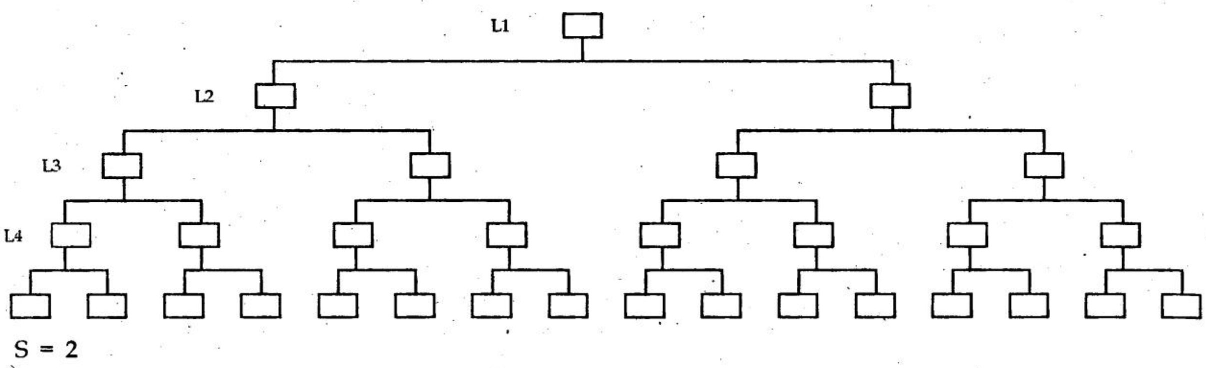

Fig 6.3 Narrow or Tall Structure, Span = 2, Level=4

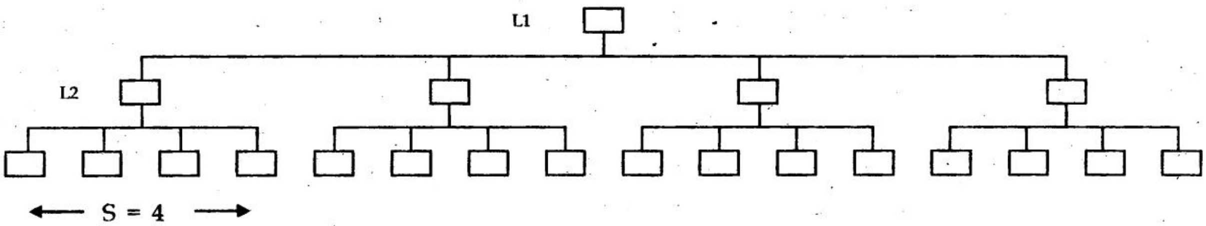

Fig 6.4 Wide or Flat Structure, Span = 4 Level = 2

Now a day a tendency toward wide span of management is increasing because of (1) the trend of decentralization (2) increasing size of organisation (3) need for quick decision making (4) faster communicant techniques and (5) growing acceptance of group processes and new patterns of leadership.

Difference between tall and flat structure is as follows :

No.	Tall (narrow) Structure	Flat (wide) Structure
1	Centralisation and close control.	Decentralistaion and loose control.
2	Better coordination due to inter-locking network.	Difficulty in co-ordination.
3	Less mistakes due to close super-vision.	More mistakes due to loose supervision.
4	Good for staff desiring detailed guidance.	Good for staff requiring independence, challenge and responsibility.
5	Distorted and delayed communication.	Speedy and improved communication.
6	Costly because of overheads.	Less supervisors and less overheads.
7	Slow decision making.	Faster decision making.
8	Greater distance between top and bottom.	Lesser administrative distance.
9	Less pressure on managers	High pressure on managers.
10	Less opportunity for development of subordinates.	More such opportunity.
11	Less competent subordinates can be employed.	Competent and willing subordinates are required.

5.4 Delegation and Decentralisation of Authority :

(A) Delegation of Authority :

Definitions :

1. **F.G. Moore –** Delegation means assigning work to others and giving them authority to do it.

2. **Koontz & O'Donnell –** Authority is delegated when decision making power is vested in a subordinate by superior.

3. **Koontz & Cyril O-Donnell –** The entire process of delegation involves the determination of results expected, assignment of tasks, delegation of authority for accomplishment of these tasks and exaction of responsibility for their accomplishment

4. **Dr. Terry -** Delegation means conferring authority from one executive or organisation unit to another in order to accomplish particular assignments.

5. **Louis A.** Alien -It is a process a manager follows in dividing the work assigned to him so that he performs that part which only he, because of his unique organisational placement, can perform effectively and so that he can get others to help him with what remains.

   Allen says "once a man's job grows beyond his personal capacity, his success lies in his ability to multiply himself through other people" (i.e. delegate his work to others).

6. O. **Jeff. Herris** - Delegation of authority is the delivery by one individual to another of the right to act, to make decision, to requisition resources and to perform other tasks in order to fulfil job responsibilities.

7 **E.F.L. Breach -** Delegation means the passing on to others of a share in the four elements of the management process, that is to say, in the command of the activities of other people and in the responsibility for the decision making that will determine the planning, co-ordination and control of the activities of such other people.

Thus, delegation means assigning work to others and giving them authority to do it. It gives right to decision making in certain defined areas and charging subordinates with responsibilities for carrying Out those assigned tasks.

Characteristics:

1. A superior grant some authority to a subordinate who must act within the limit prescribed.
2. Entire authority cannot be delegated.
3. Responsibility cannot be delegated. No manager can escape from his obligation by delegating it authority to subordinates.
4. Delegation does not reduce the authority of a manager. It is retained even after delegation. Manager can reduce, alter, enhance or take back the delegated authority.
5. Delegation may be specific or general, written or oral, formal or informal. It does not mean i avoiding decisions or abandonment of work.
6. It is an art because it is creative, practice based, involves personal skills, result oriented and b personalised process.

Importance of Delegation:

1. Human capacity is limited. By delegation, a manager can distribute his workload to others and he can concentrate on more important policy matters.
2. It facilitates quick decisions because the authority to decide lies near the point of action. Subordinate can decide easily and quickly.
3. It enables to obtain specialised knowledge and expertise of subordinates.
4. It improves job satisfaction, motivation and morale of subordinates. It satisfies their needs of recognition, responsibility and freedom. It prepares a second line of command which is always useful.
5. It increases interaction, understanding and healthy relationship with subordinates. It binds group members together.

6. It is an aid to executive development. It facilitates expansion and diversification of business through a team of competent and experienced workers.

Process (Elements) of Delegation : It involves four steps (1) Results are defined before delegation (2) Assignment of duties (3) Granting of authority and (4) Creating accountability for performance.

Degree of delegation is classified as over-delegation or under-delegation.

Obstacles of delegations are reluctance to delegate (by managers), reluctance to accept delegation (by subordinates) or if both are ready there are organisational weaknesses like inadequate planning, splintered authority, lack of unity of command, absence of control techniques, non-availability of competent persons, unclear authority, internal distrust etc.

Principles of Delegation:

1. Define functions (job, target, results) before delegation.
2. Delegate authority and power necessary.
3. Parity (balance) of authority and responsibility should be maintained.
4. Responsibility cannot be delegated.
5. Unity of command i.e. a subordinate should be responsible to one superior only.
6. Limits of authority of each subordinate should be well defined.
7. Authority level principle i.e. each subordinate should take decision within his jurisdiction only and matters beyond his scope of authority should be referred to superior.
8. Scalar principle i.e. chain of authority should go without break from top to bottom in organisation structure. Each employee should be aware of the source from which authority and command flow up to him and to whom he should report his work .and difficulties.

(B) Decentralisation of Authority':

Definitions:

1. **Henry Fayol** - Everything that goes to increase the importance of subordinates' role is decentralisation, everything which goes to reduce it, is centralisation.

2. **Joseph Meassie** - Decentralisation is an organisational concept which takes decision making to the lower levels of organisation.

3. **Newman, Summer and Warren-** It is nothing but distribution of managerial functions and assignment of definite responsibilities to various managerial units.

4. **Keith Davis** - Dispersal of authority and duties to the lowest unit in the organisation so far as it is feasible is called decentralisation.

5. **E.E.L. Breach** - It is the pattern of responsibility arising from delegation.
6. **Earnest Dale -** It is the delegation of business decisions by the owners to their immediate representatives and then to others further down in the management hierarchy.

7. **Louis A. Alien-** It is the systematic effort to delegate to the lowest levels all authority except that which can be exercised at central points.

Decentralisation is associated with fundamental principle of democratic management. Centralisation and decentralisation are relative and opposite terms. Neither 100% centralisation nor decentralisation is desired or possible. Proper balance between them is required depending on nature and span of the management.

Difference between Delegation & Decentralisation:

No.	Delegation	Decentralisation
1	It is a technique of management.	It is a philosophy of management.
2	Relationship between superior & subordinate.	Relationship between top management and other department or divisions.
3	It is essential and useful.	It is optional. Management may or may not disperse authority.
4	Person who delegates, holds control over subordinates.	Control is delegated to departmental heads.
5	It is a process or an act.	It is the end result of delegation.
6	Delegation is possible without decentralisation.	Decentralisation of not possible without delegation.

Advantages & Disadvantages of Decentralisation :

No.	Advantages	Disadvantages
1	Relief a top executives.	Difficulties of co-orindate.
2	Motivation of subordinates.	Expensive (staff cost).
3	Executive development.	Problems of control.
4	Quick decisions.	Internal constraints.
5	Effective communication.	External constraints e.g. market, unionism, Govt. policy.
6	Efficient supervision and control.	Harmful in emergency.
7	Growth & diversification.	Loss in staff service.
8	Development of initiative and responsibility.	Lack of uniformity.
9	Boosts morale.	Narrow product lines.
10	Simplifies division of work.	Pressure increases on departmental heads.
11	Development of leadership.	Importance and effect of superior are decreased.
12	Stability and continuity.	
13	Flexibility.	
14	Develops harmony.	
15	Preserves grip on market.	

Degree of Decentralisation : Earnest Dale has given four tests to measure degree of decentralisation-

1. Number of decisions.
2. Importance of -decisions.
3. Effects of decisions.
4. Checking of decisions.

Effective Decentralisation : This requires

1. Proper balance between centralisation & decentralisation.
2. Centralised authority to decide proper decentralisation, co-ordination and to resolve its problems.
3. Good number of competent managers.
4. Effective and speedy communication.
5. Adequate controls to distribute resources, assign costs, lay down standards and norms.
6. Willingness of the top management to share authority downward.

Factors determining Decentralisation : They are-

1. Size and complexity of the organisation.
2. History of the organisation.
3. Nature of functions.
4. Scattered operations of production, sale etc.
5. Planning and control procedures.
6. Degree of diversification.
7. Complexities of the situation.
8. Availability of competent personnel.
9. Communication system and
10. Outlook of the top management

6 SAFETY MANAGEMENT AND ITS RESPONSIBILITIES

6.1 Safety Management Defined :

We have seen the definitions of management in the foregoing Part 3 Based on this, we can define the safety management as The accomplishment of safety objectives by first establishing the safety objectives and then by attaining them through the process of planning, organising, staffing, directing and controlling i.e. motivating and co-ordinating all efforts to attain those objectives and also innovating to improve them for the future.

Safety organisation (higher level management) ;can also be defined as a definite, planned and organised set up whose purpose is to enlist and maintain the combined efforts of organised personnel for the purpose of total loss control including accidents and environmental protection in an industry or establishment.

In a small unit where there is no safety officer or department or group of persons for safety activity, even a single person - supervisor, occupier or Worker-should assume the duty of safety management.

6.2 Place of Industry in Society and Safety in Industry :

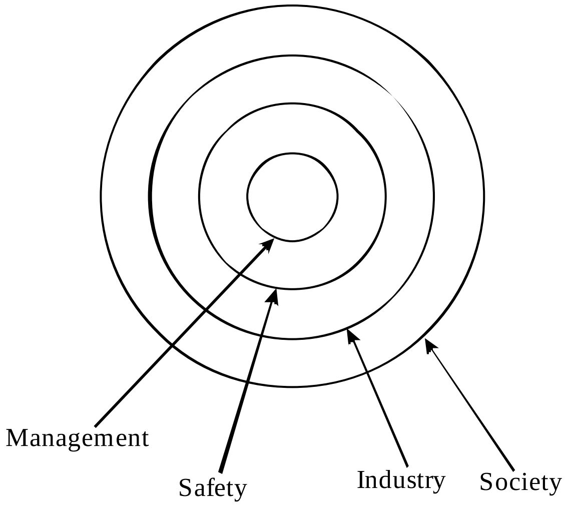

Fig. 6.5 Place of Safety Management

Industries are inevitable in modern society because human needs of foods, clothes, homes, amenities, luxuries, services and knowledge are to be fulfilled. It is also required for employment. Wants of modern society are day by day increasing with the increase in population, invention, technology, industrialisation and human desires. How to produce, distribute and supply all such wants to the whole humanity? Mass production is possible by industries only. Distribution and supply are possible by trade and business. Therefore place of industry is ahead, vital and most desirable. We cannot eliminate industry from society. Only its hazards are to be eliminated and for this purpose, the safety management is desired. As place of industry in society is inevitable, similarly the place of safety in industry is also inevitable, because safety is -most required in industries.

Industrialisation has been defined by Dr. Luigi Parmeggiani as "the process of change in the mode of production to utilise more capital per unit of output, higher levels of technology and management, widening markets with cost economics of scale and specialised location of plant, type .of plant and skills".

Industrialised country has been defined as one that derives more than 30% of its gross domestic product (GDP) from manufacturing, while a semi industrialised country derives 20 to 30%, an industrialising country between 10 to 19% and a non-industrial country less than 10% from the same source.

Accident problem created by the industrialisation is already discussed in Chapter - 1 & 5. Increasing number of accidents and their costs with rapid Industrialisation call for accident prevention work. This is an essential task for every management. Occupational hazards, accidents and diseases, are to be prevented by providing protection to men and machines, by good maintenance, medical health checkups, good working and living conditions, prompt and effective legislation and last but not the least by constant education, training and motivation of workers to work safely. Thus, a place of safety in industry must be accepted and strengthened by providing efficient safety management.

6.3 Safety Management's Role :

This is a manyfold role as described in eleven heads as under -

6.3.1 General and Scientific Functions :

The basic safety role of any industrial management is well derived from the five steps of accident prevention suggested by H.W. Heinrich. These are organisation, facts finding, analysis of the facts found, selection of remedy and application of the remedy..

The Scientific Method of Management considers more productive or improved method of management by careful and accurate classification of facts, their sequence and correlation, discovery of scientific laws and its impartial application, new concepts, experiments and observations. The six functions of scientific safety management are:

1. **Planning :** It includes setting safety objectives, formulating safety policy, safety programming, budgeting and determining safe or standard procedures. Good planting at the design stage always helps. Planning for site, effluent disposal, facilities for storing and handling raw materials, intermediates and products, types of floor, roof, construction, lighting, ventilation, layout of machinery, pressure vessels, lifting machines, hazardous processes, boilers, storage tanks, repair services, auxiliaries, utilities, fire protection, training, welfare and sanitary facilities etc., must consider safety points at this initial stage so that the planning and design defects can be eliminated or minimised from the beginning. Previous plans approval and correction after operation are also necessary.

2. **Organising :** It includes establishment of the formal structure of authority through which work subdivisions are defined, arranged, and co-ordinated for the planned safety objectives.

An organisational set-up describes four classes of management - Top or Executive, Intermediate, Middle and Supervisory management. The set-up may vary according to the size and nature of establishment. A model safety organisation is shown in Fig 6.6.

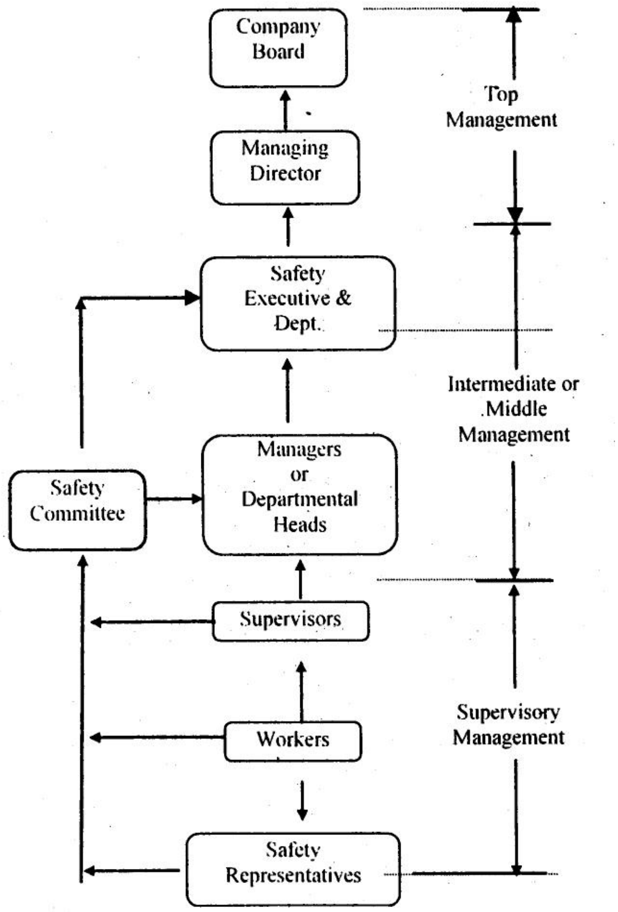

Fig. 6.6 Organisational Set-up (Structure)

The Company Board decides the safety policy and objectives and monitors its implementation. Managing Director is reportable to the Board for implementation of safety policy. Safety executive or safety department reports to MD. Managers are answerable to the Safety Department or Executive for application of the safety arrangements. Supervisors are reportable to the Managers for shop floor extension and application of safety policy, rules and procedures. Workers are responsible to their supervisors for effectively carrying out the safety rules and precautions. Safety Representatives selected from workers and supervisors advise and assist to Safety Committee for promoting health and safety. Safety Committee advises on all matters of safety and health to the Managers and the Managing Director.

3. **Staffing :** It includes personnel function of recruitment and training the staff and maintaining safe and favourable conditions of work through personnel.

4. **Directing :** It is a continuous task of taking decisions, ordering, instructing, guiding and advising on all maters of safety.

5. **Controlling :** It includes performing, evaluating and correcting the performance according to objectives, procedures and plans. It is concerned with quality, times, uses and cost in safety matters.

6. **Co-ordinating :** It includes interrelating and synchronising the different activities for achieving safety goals.

Let us see these functions one by one -

6.3.2 Planning for Safety :

Planning is the most fundamental and the first function or element of management process. Other functions rest on it- Need for planning is increasing because of changes in technology, materials, methods, processes, demands, law, government policy, procedure and competition.

Definitions of General Planning :

1. **Henry Fayol** - Planning refers to a preview of future activities.

2. **UrWick** - It is fundamentally a mental predisposition to do things in an orderly way, to think before acting and to act in the light of facts rather than of guesses.

3. **Haynes & Massie** - Planning is that function of manager in which he decides in advance what he will do. It is a decision making process of a special kind, its essence is futurity.

4. **Koontz and O'Donnell** -It is an intellectual process, a conscious determination of course of action, the basing of decisions on purpose, facts and considered estimates.

5. **George R. Terry** - Planning is the selecting and relating of facts and using of assumptions regarding the future in the visualisation of formulation of proposed activities believed necessary to achieve desired goals.

6. **Dalton McFarland -** It is defined as the activity by which managers analyse present conditions to determine ways of reaching a desired future stage. It embodies the skills of anticipation, influencing and controlling the nature and direction of change.

7. **Theo Haimann** - Planning is the function that determines in advance what should be done. It consists of selecting the enterprise objectives, policies, programmes, procedures and other means of achieving these objectives.

Planning is a process, as explained by above tinkers, and a 'plan' is the outcome of this process.

'Safety Planning' defined : From above general definitions, we can define safety planning as the first step of safety management wherein a safety manager decides in advance safety objectives, policy, procedure, strategies, rules, programmes, methods, budgets, schedules and necessary means for achieving these objectives, considering facts (of accidents and other hazards) and anticipating foreseeable events that may affect safety of plant, people and environment.

Purpose (importance) of General Planning : Purpose, importance, significance, advantages or utility of planning are summarised as under –

1. Focuses on. objectives and results.
2. Activities become purposeful and orderly.
3. Reduces uncertainly, risk, wastage etc.
4. Helps in controlling future events (loss).
5. Helps in saving of costs.
6. Imparts accuracy.
7. Helps other functions of management i.e. organising, staffing, budgeting, directing, controlling etc.
8. Provides direction.
9. Creates healthy organisational climate.
10. Provides framework.
11. Helps to visualise a clear and complete picture of the business or activity.
12. Secures co-operation from employees.
13. Maintains balance between various activities.
14. Encourages innovation and creativity.
15. Guides decision making.
16. Provides basis for decentralisation.
17. Provides efficiency in operations.

Purpose (Areas) of Safety Planning : It includes all above 17 aspects with reference to health and safety of workers and public, safety of plant and surrounding environment, and prevention of total losses. Some subjects of safety planning are given below.

1. To draft health and safety policy and environmental policy for the management.
2. To decide safety committee, its objectives and effective functioning.
3. To decide safety targets like zero/minimum accidents, maximum working hours without accident, safety education, training and awareness programmes for the workers and the public.
4. Areas of hazards and their detection, inspection, audit, risk assessment and measures for their removal or minimisation.
5. Accidents investigation, analysis, costs calculation and introducing safety measures to prevent their recurrence.
6. Organisation structure, staff, key persons and their roles for safety.
7. Standards for safety equipment, tools, permissible exposures etc.
8. Preparation, rehearsal and updating of on-site emergency plans.
9. Details of safe or standard operating procedures (SOP), close-down procedures, methods, fire fighting procedures, emergency preparedness, first-aid etc.
10. Testing, inspection and records of lifting machines, pressure vessels, ventilation, lighting, safe environment etc., as per statutory need.

11. Medical examination of workers, records and corrective action as directed by doctors.
12. Compliance of statutory and non-statutory safety provisions, their records and reporting.
13. Search for safe and clean technology for the process and hazard control techniques for detection and removal of all hidden hazards.
14. Follow-up action, evaluation of safety programmes and improvement of future plans, strategies etc.
15. Planning to achieve national and international standards, awards etc.

Nature of Planning : Nature, features or characteristics of planning are as under

1. It is a primary and most important function of management.
2. It is goal oriented.
3. It is an intellectual or rational process.
4. It is pervasive, it encompasses all levels of management.
5. It is a continuous process (function).
6. It is conscious activity.
7. It is flexible.
8. Forecasting or forward looking is the essence of planning.
9. Accuracy is essential to planning.
10. It is a choice of alternatives.
11. It is concerned with group objectives.
12. It is an integrated process.
13. It is directed towards efficiency and achievement of decided goals.

Factors (Limitations / Constraints) affecting scope of Planning : They are :

1. Inaccuracy.
2. Time consumption.
3. Rigidity.
4. Cost.
5. Attitudes of management.
6. Faults in planning system i.e. lack of reward, lack of participation or specific activities and incompetence of the planner.
7. Lack of orientation and training for managers.
8. Uncertainty.
9. Resistance to change.
10. False sense of security.
11. Environmental constraints i.e. technological, social, legal, economic and other outside forces.

Effective Planning:

According to Gray Dessler, managers should consider following points to plan effectively.

1. Develop accurate forecasts.
2. Gain acceptance for the plan.
3. Plan must be sound one.
4. Develop effective planning organisation.
5. Be objective.
6. Measure firm's market value.
7. Decide in advance the criteria for abandoning a project.
8. Set up a monitoring system.
9. Revise long-term plans every year.
10. Fit the plan to the situation.

Plans should be simple, easy to understand, clear to followers, selective, thorough, based on well defined objectives, flexible to adopt changes, balanced, comprehensive, economical, practical and should provide standards for evaluation procedure and, proper analysis and classification of actions.

Procedure (steps) of Planning : Basic steps in planning are as under

1. Identify problems.
2. Establish objectives (goals).
3. Develop 'planning premises' (e.g. land, labour, capital, market, money, time, production, public relation, employee relation, reputation, morals, policy, programmes, rules, emergencies, new inventions, population trends, supply position; economic, technological, political and social conditions etc.)
4. Determine alternative courses of action.
5. Evaluate the alternatives.
6. Select a course of action.
7. Formulate derivative (final) plan and sub-plans as per need.

These procedural steps are to be applied in planning for safety. Here planning premises for safety would be safely objectives, safety standards, safety procedures, safety rules, safety provisions, safety training, safety programmes, safety policy, committee, inspection, audit, analysis, assessment, accident analysis, other control methods, forecasting of emergencies and planning for that, development of new methods, purchase policy, safety equipment, safety reports & records, use of new material, process or technology, process revision and various subjects of safety including fire, explosion, toxic exposure etc.

A safety manager requires wide knowledge and help of other departmental heads, consultants, experts etc., while planning on above specialised areas.

Range of Planning : Based on time schedules three types of plans can be prepared as under-

1 **Short-term (operational) plans** - For a period up to one year. They are specific and detailed and cover forms and contents of long term plan. They are prepared on the basis of strategic and tactical plans. Examples are daily operations, repairs and maintenance plan, purchase plan, product plan, activity planning, working methods, procedure, accident investigation & analysis, inspection techniques, induction training etc.

2 **Medium-term (intermediate) plans** - For a period of more than one year and less than 5 years. They are co-ordinative and tactical in nature. They are less detailed than short-term plan. Examples are proposed product and its safety aspects, emergency planning and forecasting of emergencies, refresher courses etc.

3 **Long-term (strategic) plans** - For a period of 5, 10, 15 or more years. It considers future changes in environment and provides overall targets toward which all activities of the organisation are to be directed. It results in long term commitment of resources. It takes a macro view of the organisation and provides direction for the growth of the enterprise. It involves uncertainty because of the long period. Examples are environmental impact assessment, future opportunities, scientific development and its forecasting, future need of people and market trends, future expansion, competition etc.

Variety (types) of Plans : They are classified as under -

1. Based on objectives - Production plan, sales plan, financial plan, investment plan, expansion plan, research and development plan, training plan, existing business plan, reform oriented plan etc.
2. Based on time - Short, medium and long term plans as explained earlier.

3. Single use plan - Programmer projects, budgets etc.
4. Repeated use (standing) plans - they consider objectives, policies, procedures, rules and strategies.

Strategic Planning:

The word 'strategy' is used in military indicating its art (technique) of fighting the enemy. In business or industry it means a special type of plan to meet challenges, competitions, emergencies and other environmental forces. On-site and off-site emergency (contingent) plans are the best examples of such strategic planning. Their details are given in Part 7 of Chapter - 19. Strategic Plan is a master plan for the whole company and is framed by the chief executive, top level management or experts on the subject.

Definitions:

1. **McFarland** - Strategy is the executive behaviour whose purpose is to achieve success for the company or personal goals in a competitive environment based on the actual or probable action of others.

2. **Stoner and Wankel** - Strategic planning is the formalised, long range planning process used to define and achieve organisational goals.

3. **Koontz and Weihrich** - Strategic planning means to analyse the current and expected future situation, determine the direction of the firm and develop means for achieving the mission.

4. **D. L. Cleland and W.R. King** -Strategy is the complex plan for bringing the organisation from a given posture to a desired position in a future period of time.

Thus strategic planning links the resources of the organisation with the risks and challenges posed by external forces and lays down a long-term direction for the enterprise. In this sense strategic safety plans means on-site and off-site emergency plans to fight internal and external grave emergencies and long-term s public awareness and involvement programmes to deal with public or massive emergency due to industrial disaster.

Nature (characteristics) of Strategic Planning :

1. It is a long-term planning to fight future external forces.
2. It is action oriented, flexible, dynamic and forward looking.
3. It deals with basic questions.
4. It is a function of the top management.
5. It becomes a base for the detailed plans.
6. It focuses on energies and resources.
7. It analyses the environment.
8. It evolves assumption of certain calculated risks.
9. It is a contingent plan to meet demands of a particular situation.

Essentials (evaluation) of a good strategic plans:

Factors governing are.:
1. Internal consistency.
2. Consistency with environment.
3. Appropriate time horizon.
4. Realistic.
5. Acceptable degree of risk.
6. Feasibility and

7. Social or legal sanction.

Need of Strategic Planning : Need, advantages or importance of strategic planning are :

1. Helps in facing environmental or future challenges.
2. Provides direction.
3. Improved functioning.
4. Exploiting favourable opportunities.
5. Minimisation of chances of mistakes or losses.
6. Effective/efficient utilisation of resources like time, money, talent, equipment etc.
7. Facilities co-ordination and control
8. Competitive strength.

Process (steps) of Strategic Planning :

1. Decide mission and long range objectives.
2. Collect and analyse relevant information.
3. Assess the environmental and risk factors.
4. Conduct - resource audit (self-appraisal).
5. Think of strategic alternatives.
6. Select the best alternative (decision making).
7. Implement and control it.

Develop programmes and budgets for each function. Short term operational plan should b(prepared to utilise the resources. Proper sequence and timing efforts are decided to take every step at the right time. Performance should be evaluated, where result; are below expectations, strategy should be reviewed and modified as per need.

6.3.3 Organising for Safety :

Meaning:

The term 'organisation' is used in management in different ways as under

1. It refers an activity, process or function of management i.e. organising.
2. It is used in a dynamic way referring to e process by which the structure is created maintained and used.
3. It is used in a static way referring a static structure (skeleton) of responsibilities anc authorities i.e. a network & relationships among individuals and positions in an organisation.
4. It refers to an ongoing business unit i,e. a unit which is purposefully created to attain some objectives with resources.

Definitions:

1. **Joseph L. Massie -** Organisation is defined as the structure and process by which co-operative group of human beings allocates its tasks among its members, identifies relationship and integrates its activities towards common objectives.

2. **McFarland -**It is an identifiable group of people contributing their efforts towards the attainment of goals.

3. **Haimann-** Organising is the process of defining and grouping the activities of the enterprise and establishing the authority relationships among them. In performing the organising function, the

manager defines, departmentalises and assigns activities so that they can be most effectively executed.

4. **Chester Barnard** -It is a system of co-operative activities of two or more persons.

5. **L .Urwick** - Organisation is the process of dividing up of the activities which are necessary to any purpose and arranging them in groups which are assigned to individuals .

6. **John Pfiffner** - It is essentially a matter of relationship of man to man, job to job and department to department.

7. **Mooney & Reily** -It is the form of every human association for the attainment of a common purpose.

8. **Kimball & Kimball** - Organisation is subsidiary to management. It embraces the duties of designating the departments and personnel that arc to carry on the work, defining their functions and specifying the relations that are to exist between departments and individuals.

9. **Louis Alien** - Organisation is a process of (i) identifying and grouping the work to be performed (ii) defining and delegating responsibility and authority and (iii) establishing relationships for the purpose of enabling people to work most effectively together in accomplishing objectives.

10. **G. R. Terry** - Organising is (i) the establishing of effective behavioural relationships among persons (ii) so that they may work together efficiently and (iii) gain personal satisfaction in doing selected tasks (iv) under given environmental conditions (v) for the purpose of achieving some goal or objectives.

11. **Johnson, Kast and Resnzweig** - Organisation is an assemblage of people, materials, machines and other resources geared to task accomplishments through a series of interaction and integrated into a social system.

The main points that follow from above definitions of organisation are :

1. A business unit is divided into different sections or departments.
2. Each section or department is assigned a definite function or duty.
3. The authority and responsibility of each section or department or a group of people are clearly defined.
4. The interrelationship among various departments and among the groups of people working in them is clearly specified.

See Fig. 6.7 for a general organisation structure.

Fig 6.7 - Organisation Structure

Safety Organisation defined : Inferring from above general definitions. Safety organisation can be defined as the structure and process by which groups of people (employees) are divided into sections or departments, each section or department is assigned specific safety function or duty. Authority and responsibility of everybody is clearly defined and interrelationship between them is specified for the accomplishment of organisational safely goals.

A large unit may have safely department which may have groups of people for division of such safety function and responsibilities. But in a small unit (majority) if such division is not possible and only a few persons are available for safety work, they will be assigned specific duty and other departmental heads (production, purchase, personnel etc.) will be explained their role and responsibility towards safety goals. All supervisors shall be integrated with safety as part of their duty. 'Safety is everybody's duty' will be explained to all with their safety duty given in writing or by displaying at their workplaces.

Need (Significance) of Organisation : Organisation is the foundation or framework of the whole structure of management and contributes greatly to success and continuity of an enterprise in the following ways -

1. Facilitates administration and other functions of management process.
2. Facilitates growth and diversification.
3. Permits optimum use of technological improvements.
4. Encourages use of human beings.
5. Stimulates creativity.
6. Attains maximum efficiency with minimum costs.

Planning is the brain of a business unit while organisation is its physical structure. All managerial functions like planning, directing, co-ordinating, controlling, budgeting, staffing etc. are performed %· through the medium of organisation.

Its importance is remarkably explained by Andrew Carnegie (American industrialist) : "Take away our factories, take away our trade, our avenues of transportation, our money. Leave us nothing but our organisation, and in four years we shall have re-established ourselves".

Nature (Characteristics) of Organisation : Briefly they can be stated as under

1. It is a set up to realise the objectives (common purpose).
2. It is a co-operative activity.
3. It is a process (function) and structure both.
4. Division into Departments or groups. Division of labour.
5. Delegation of authority and responsibility. The chain of superior - subordinate relationship is known as 'chain of command'. (Authority structure).
6. Importance of human element (people).
7. Vertical and horizontal relationship between man to man, job to job .and department to department.
8. It is closely linked with planning. Other functions of management are not possible without organisation.
9. It is flexible and accommodates environmental changes.
10. It is stable and resists challenges.
11. Provides supervision, control and review.
12. Provides mechanism of co-ordination.
13. Provides channels of communication.
14. Provides policies, procedures, rules and regulations for systematic functioning.
15. Backbone of management and regenerates everything from beginning.

Principles of Organisation (Features of a good Organisation Structure) : They are summarised as under

1. Unity of objective - all are geared to common objectives.
2. Span of control - each superior has limited subordinates to report him.
3. Unity of command - each subordinate has only one superior to get command.
4. Scalar principle - clear chain of command from top to bottom.
5. Co-ordination - should exist among all individuals and groups.
6. Communication - should be open and clear.
7. Facilitates leadership.
8. Parity of authority and responsibility - exist by way of delegation.
9. Exception principle - only matters beyond control may be referred to higher levels.
10. Functional definition - Functions (duties), authority and responsibility of every position should be clearly defined so as to avoid duplication or overlapping.
11. Efficiency - optimum use of resources at minimum possible costs.
12. Flexibility - should accommodate changes.
13. Stability - should resist challenges.
14. Continuity - by training and development of executives and employees.
15. Balance - between centralisation and decentralisation.
16. Division of work - one member one function.

17. Unity of direction - clear-cut direction at all levels. Directions should be simple, easy to understand and unambiguous.

18. Simplicity and clarity - they add to efficacy of organisation.

Organisation for Safety: See Part 6.3.1 of this Chapter 'General and Scientific Functions'.

Safety Department : See Part 8 of this Chapter.

Safety Committee : See Part 11.3.1 of this Chapter.

Types of Organisation : There are seven types of organisation:

1. Line, military, scalar or vertical organisation.
2. Line & staff organisation.
3. Functional organisation.
4. Product organisation.
5. Project organisation.
6. Matrix organisation, and
7. Committees.

In 'Line organisation' line of authority is vertical flowing from top to the bottom and no staff specialists. In 'Functional organisation' the whole task is divided' into specialised functions (departments) and horizontal relationships also exist.

Line & Staff Organisation : 'Line & staff organisation' is a combination of line and functional structures, line of authority flows in a vertical line, but staff specialists are attached to line positions to advise them on important matters and these specialists do not have power of command over subordinates in other departments, but they possess it over subordinates in their own department e.g. Chief Safety Officer has command over safely officers in his department but he has no command over accounts officer in other department. He has only advisory relationship with other departments like production, personnel, HRD etc. A common model of line & staff organisation is shown in Fig. 6.8.

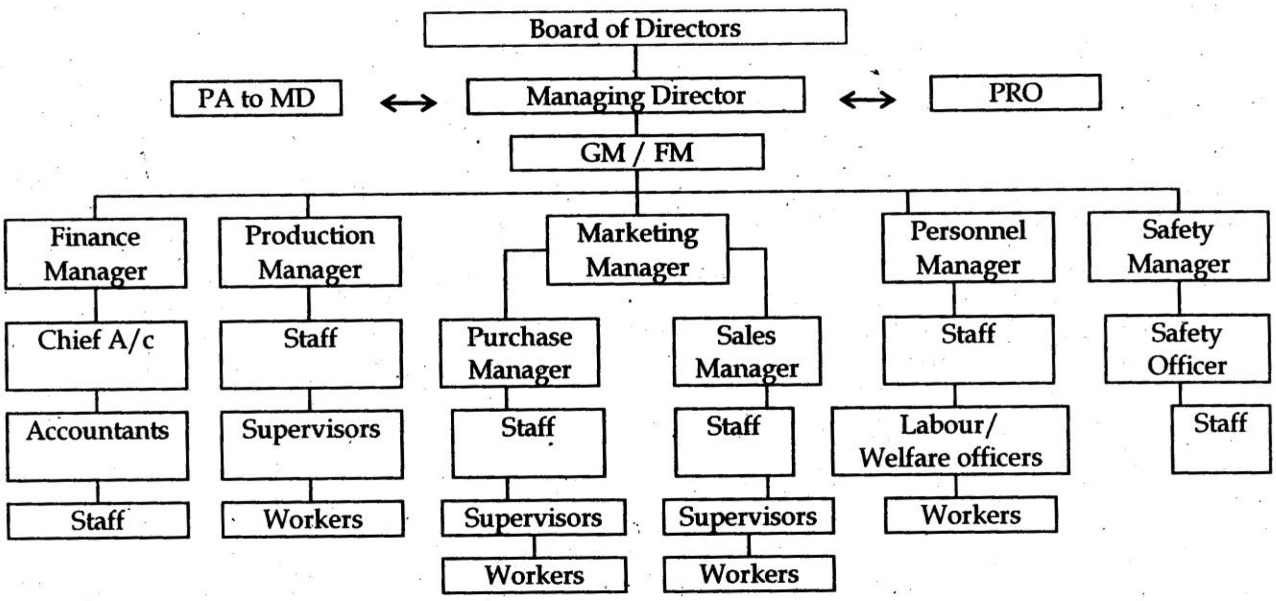

Fig. 6.8 : Line and Staff Organisation

No.	Advantages	Disadvantages

1.	Relief to line managers	Line-staff conflicts
2.	Expert advice (specialization)	Confusion in relationships
3.	Better decisions	Staff becomes ineffective or irresponsible
4.	Training of personnel	Expensive for small units
5.	Flexibility – opportunity for advancement	

Line & Staff Function of Safety :

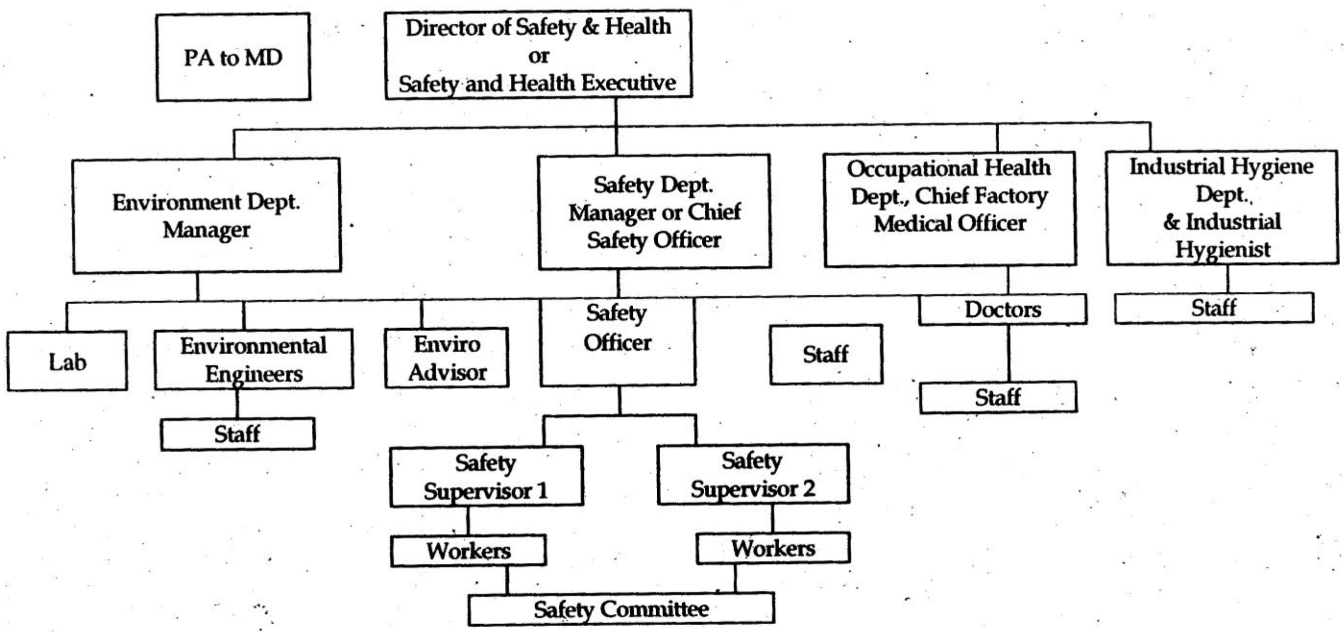

Fig. 6.9 : Line & Staff Organisation for Safety

One model of line & staff organisation for safety is shown in' Fig 6.9. For another model see Fig 6.6 of this Chapter.

Director or Safety & Health Executive is at the D of the line of authority. He has PA for assistance. Under him there are Managers for Safety, Occupational Health, Industrial Hygiene and Environment departments. They are reportable to Director but not to each other. They may consult or advise each other but cannot compel work. Safety Manager has Safety Officer(s) with staff. They have Safety Supervisors under them who supervise their respective areas and workers allotted to them. Similarly Health department has doctors under them with OHC. Environment dept. has enviro engineers, lab and staff.

Functions of safety department are mentioned in details in Part - 8 and Part - 6.3.1 and 6.3.2 of this Chapter.

6.3.4 Directing for Safety :

Meaning:

Once the objectives are decided and planning is made how to achieve them, organisation structure is designed by staff, appointing qualified and experienced persons and the organisation can be said ready for action. But this action cannot begin until orders and instructions are issued i.e. the employees are 'directed' to carry the orders. This process of inspiring and guiding people what to do and how to do the best of their ability is known as 'directing'.

Thus after planning, organising and staffing,, directing is the fourth managerial function. It is that part of the management process which guides, inspires, instructs and harnesses people to work effectively and r efficiently to achieve the goals.

Definitions:

1. **Urwick and Brech** - Directing is the guidance, the inspiration, the leadership of those men and women that constitute the real core of the responsibility of management.

2. **J. L. Massie -** Directing concerns the total manner in which a manager influences the actions of subordinates. It is the final action of a manager in getting others to act after all preparations have been completed.

Process : The process of directing consists of , the following steps :

1. Issue orders and instructions. They should be clear, complete and within capabilities of the followers.
2. Provide and continue guidance and supervision to ensure that the assigned tasks are carried out effectively and efficiently.
3. Maintain discipline and reward for good work.
4. Inspire and motivate to work hard to achieve the goals.

Thus motivation, supervision, leadership and communication are the main elements of directing.

Nature of Direction : The main characteristics of directing are:

1. Pervasive function - every manager has to guide and inspire his subordinates.
2. Continuing or on-going function.
3. Linking junction between preparatory functions (planning, organising and staffing) and controlling.
4. Creative function - It converts plans into performance. It is the management in actions. It brings life for organisation.
5. Human factor - involves human behaviour for which motivation is useful
6. Chain of command - It flows from top to bottom. Each superior directs his subordinates.

Role (benefits) of Direction :

It (1) initiates action (2) ensures coordination (3) improves efficiency and effectiveness (4) facilitates change and (5) assists stability and growth.

Principles of Direction : They are :

1. *Harmony of objectives* - Management should take care of personal goals of employees with the organisational goals.
2. *Unity of command.* - One subordinate should get orders/instructions from one superior only.
3. *Direct supervision* - There should be personal or direct supervision.
4. *Good communication* - Helps to improve understanding and speed of work.
5. *Maximum contribution* - Managers should try to get maximum possible contribution from each subordinate.
6. *Appropriate techniques* - The techniques should be suitable to superior, subordinates and situation to get efficiency.
7. *Strategic use of informal organisation* - Some informal groups should be contacted to decide direction.

8. *Comprehension* - Orders should be clear, complete and understandable.
9. *Good Leadership* - Managers should guide and counsel subordinates to win their confidence and trust.
10. *Follow-up* - Managers should follow-up their orders and modify if necessary.

Techniques of Direction : Generally four techniques are available for directing. They are delegation of authority, supervision, orders and instructions.

By delegation of authority a superior entrusts his subordinates with certain rights or powers. He assigns a part of his work and authorises him to do work.

Supervision means expert overseeing of subordinates at work to ensure compliance of plans and procedures. At operating level it is most useful and effective.

The terms order, instruction, directive and command are used interchangeably in management literature. They mean to initiate , modify or stop an activity. It is a primary tool by which activities are started, altered, guided and terminated.

Above definitions, principles and techniques of direction are equally applicable to the area of safety and safety managers should know an4 follow them while guiding, inspiring, motivating and instructing workers to detect and remove unsafe conditions and actions and to maintain safe environment in their day to day activities.

6.3.5 Leadership :

Meaning:

It is an indivisible part of the process of directing as explained in earlier part. It is a tool or means which makes direction effective. Dr. Terry says that managers have to manage business which means that they have to provide leadership. They have to instil in them desire to achieve the goals, a desire to improve their performance and a sense of co-operation. If the managers fail to provide such 'leadership the employees will search the leadership outside which may lead to conflict or distraction.

Definitions:

1. Koontz and. O'Donnell - Leadership is influencing people to follow in the achievement of common goal.
2. Terry - It is the ability of influencing people to strive willingly for natural objectives.
3. R. T. Livingston - It is the ability to awaken in others the desire to follow a common objective.

Role and Functions of a Leader :

1. He should be clear about common objectives (goals) and should communicate them clearly.
2. He has to influence, guide, instruct, inspire and supervise his subordinates to work efficiently and effectively.
3. He has to generate (awaken) desire in followers to achieve the common goal.
4. He works along with his followers, shows them how to work and gets their co-operation in return.
5. He should convince the followers that in protection of organisational (group) goals, lies the protection of their personal goals.
6. He has to provide continuous guidance till the achievement of goals.
7. Depending on situation he should alter, modify or stop order and should not be rigid in his decision.

8. He has to set an example by his own behaviour. Urwick has rightly said that It is not what a leader says, still less what he writes, that influences subordinates. It is what he is. And they judge what he is by what he does and how he behaves'.

Attributes of a Leader : Certain qualities are necessary for leadership but they must be applied at the correct place and time. Dr. Terry mentioned following qualities of a leader -

1. *Energy* - Physical and mental fitness to work by self and to guide for a longer time.
2. *Teaching ability* - He should be a good teacher.
3. *Emotional stability*- should be free from bias and anger and not emotional.
4. *Empathy* - It means the ability to understand other's viewpoint. He should have respect for others and their beliefs.
5. *Objectivity* -He should be objective to others and should find out reasons for requests or refusal by his subordinates.
6. *Enthusiasm* - is required in leader. He should be self motivated and capable of motivating others.
7. *Knowledge of HR* - Leader has to deal with human beings and therefore he should posses knowledge of human resources.
8. *Communicative skill* - He should be effective in his speech, talk and forceful impression.
9. *Social skill* - He should mix with his followers freely and socially. He should appreciate others' opinion and work with close co-operation.
10. *Technical competence* - Doubtlessly he must be technically more competent so that he can successfully teach technical aspects.

Leadership Styles (Techniques) : They are of three types -

1. Autocratic or Dictatorial leadership.
2. Democratic or Consultative or Participative leadership.
3. Free .Rein or Laissez Faire leadership.

In autocratic leadership subordinates have less freedom which increases in democratic leadership. Superior enjoys more authority in autocratic leadership arid less authority in democratic leadership. See Fig 6.10.

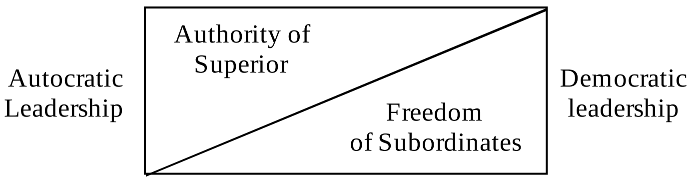

Fig 6.10 Relationship of two types of leadership

Autocratic leadership is useful when subordinates are illiterate, unskilled, untrained and secrecy in decision making is required. It can be applied when there is a clear chain of command or clear-cut division of authority. Its features are retention of power, relying on orders only and close supervision.

In **democratic or consultative leadership** method, the manager consults his subordinates and invites their suggestions before making decision. Formal or informal meetings are also held. Here subordinates work heartily because their views and opinions are respected. Close personal contacts and clear understanding of problems are ensured. It develops trust, co-operation and leadership among employees. This stage is useful when subordinates are literate, have sense of responsibility and organised. It requires much time in decision making.

In **free - rein leadership** technique, the manager delegate authority to his subordinates and they are encouraged to develop and contribute independent thought and action. This method is preferred mostly by highly educated and independent (free minded) persons. Here details are prepared by the subordinates. There is a free communication between superior and his subordinates. They don't feel difficulty in consulting each other. It is more creative and develops latent abilities of subordinates.

Selection of leadership style depends on (1) force in Manager (2) force in Subordinates and (3) force in Situation.

In Safety Management, autocratic leadership style is not suitable as safety is not to be imposed like military discipline, and involvement of employees (educated or uneducated) at all levels is required. The concept of employees participation, safety committee, safety education and training and "Safety is everybody's duty" can be well implemented by democratic or consultative leadership style. In designing safely guard or its improvement by ergonomic factors, developing safe work method, meeting safety targets by group co-operation, celebrating safety programme, creating and maintaining safety awareness and emergency preparedness, suggestions and involvement in decision-making of employees are most useful. Therefore, democratic leadership style at workers and middle level and free-rein leadership style at higher (executive) level are desirable for safety management.

6.3.6 Communication :

This is another element of the management 'directing' and also useful for» effective motivation, supervision and getting the work done.

Motivation cannot succeed without communication. It is a process involving the transmission and-reception of message, eliciting meaning in the mind of the receiver and resulting in appropriate action which is desired.

Though one way communication such as speech, posters, instruction, radio, TV has their uses, two way communications is the only effective way to transfer an idea from one mind to another. Two way communications allows for clarification and amplification.

Safety communication should be more clear, loud and effective. By good efforts create responses, desires, insight and action as soon as possible. Audio visual display, transparency arid modern teaching aid should be used for effective communication.

Definitions and Meaning:

1. **Haimann** - Communication means the process of passing information and understanding from one person to another. It is the process of imparting ideas and making oneself understand by others. It is fundamental and vital to all managerial functions.

2. **Newman and Summer** -It is an exchange of facts, ideas, opinions or emotions by two or more persons.

3. **Koontz and O'Donnell** -It is an intercourse by words, letters, symbols or messages, and is a way that one organisation member shares meaning and understanding with another.

Chester Bernard has stated "'The first executive function is to develop and maintain a system of communication".

It is communication when we speak, tell, write, read, watch, listen, hear or act or convey or transmit our message by expression or any other way of understanding feeling, attitudes, wishes, ideas, opinions, emotions, thoughts etc. Poor communication creates problem and good communication solves it.

Purpose (Role or significance) of Communication :

1. It is utmost necessary for planning, decision making, organising, directing and controlling.
2. Plans cannot be implemented without effective communication.
3. Its basic purpose is to create mutual understanding and to secure desired response.
4. Motivation and morale can be boost up.
5. Human relations can be improved.
6. Training and development is not possible without communication.
7. Co-ordination can be bridged by communication.
8. Public relations can be maintained and strengthened.
9. It increases productivity and performance.
10. It assists other functions.
11. It gives job satisfaction.
12. It is a basis of leadership.
13. It gives success to enterprise.

Process of Communication : According to Shannon and Weaver, it consists of following components or elements:

1. *Sender* - One who sends a message.
2. *Message* - What is conveyed by the sender.
3. *Encoding* - Words, symbols, gestures etc. by which the message is transmitted.
4. *Channel* -Medium or route through which, the message is passed" i.e. face to face, talk, phone, pager, radio, TV, letter etc.
5. *Receiver*- Who receives the message. He may be a listener, reader or observer.
6. *Decoding* - The process of understanding or interpreting by the receiver.
7. *Feedback* - Means reply, response or acknowledgement of the receiver that he has understood the message. It may be by words, actions or expressions. When the sender receives such feedback, the process of communication becomes complete. See Fig. 6.11.

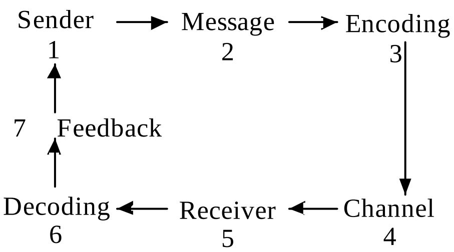

Fig. 6.11 The Process of Communication

Nature of Communication :
1. It is a continuous process. Its stoppage means stoppage of human activity.
2. It is a two way process between sender and receiver.
3. It creates mutual understanding and human relation.
4. It is a pervasive function i.e. required in all managerial functions.

Types of Channels and Media of Communication:

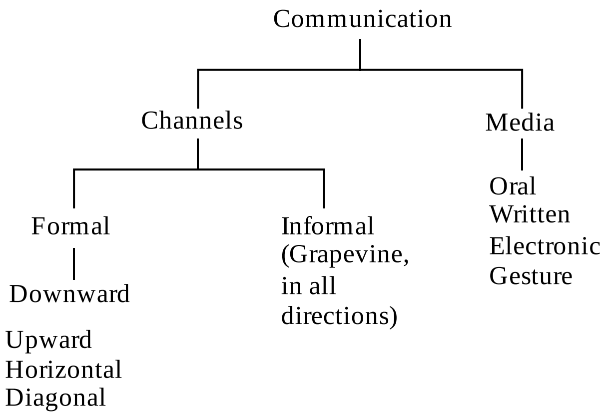

Fig 6.12 Channels & Media of Communication

A communication channel is a route through which messages flow from the sender to the receiver. It is either formal or informal. Formal (planned or systematic) communication may flow in downward, upward, horizontal or diagonal direction and creates communication networks. Informal i.e. unofficial or inter-personal (unplanned and need base) communication flows in all directions and therefore it is called structure less or grapevine. Type of communication media are oral, written or gesture i.e. implied or posture. See Fig. 6.12. Their differences are shown below:

No.	**Formal Communication**	**Information Communication**
1	Official Channel.	Unofficial Channel.
2	Intentional, deliberate, planned or systematic.	Interpersonal, unplanned or spontaneous.
3	Impersonal.	Personal and Social.
4	Slow and structured.	Fast and unstructured.
5	Stable and rigid.	Flexible and unstable.
6	Oriented towards goals and tasks.	Directed towards goals and need satisfaction.
7	Part of organisation structure.	Cuts across formal relationship.
No.	**Downward Communication**	**Upward Communication**
1	From higher to lower level.	From lower to higher level.
2	Flows downward and fast.	Flows upward and slow.
3	Directive in nature.	Non-directive.
4	Purpose is to get plans implemented.	Purpose is to provide feed back on performance or to ask something.
5	Examples: Orders, instructions, lectures, manuals, handbooks etc.	Examples: Reports, queries, Suggestions, appeals, protests, grievances, surveys etc.
No.	**Oral Communication**	**Written Communication**
1.	Generally informal.	Generally formal
2.	Involves talking and listening.	Involves writing and reading.
3.	Feedback is quick and instantaneous.	Feedback is delayed due to time of transmission.
4.	Economical.	Expensive and stable.
5.	Flexible and faster.	Rigid, slow and elaborate.
6.	Suitable for short messages.	Suitable for lengthy and organised messages.
7.	No permanent record. Hear and forget. Recording is possible	Authentic and credible record is possible.
8.	Examples : Face to face talk, group meetings, phone etc.	Examples : letters, memos, CDs, handbooks, manuals reports, Email, etc.

Difference of Types with Media:-

Oral	Written
Downward Communications :-	
Personal instructions, lectures, meetings, conferences, interviews, employee counselling, bells, whistles, telephone, movies, slides, public address system (PAS), social and cultural gatherings, union activities.	Orders and instructions, letters, Email, circulars, memos, posters, bulletin, house organs, handbooks, CDs, manuals, annual reports, policy statements, union publications, informational racks.
Upward Communications :-	
Face to face talk, oral report, exit interviews, phone, meetings and conferences, social and cultural affairs.	Personal letters, Email, written reports, CDs, suggestion scheme, grievance procedure, surveys, unions publications.
Horizontal Communications :-	
Lectures, talks, meetings and conferences, phone and intercom, movies and slides, social affairs, union activities.	Letters and memos, reports, carbons, memo, graphs, posters, bulletin, handbooks, manuals, house organs, union publications, Email.
Diagonal Communications :-	
Inter-departmental oral inquiry, talks and meetings, phone and intercom to other department, social gatherings of mixed groups.	Inter-departmental letters, memos, reports, suggestions, objections. Email etc

Tools of Communication : They are the means through which information is communicated. They can be classified as under:

Oral (Verbal) : Personal contact, talk, phone, meetings, audio, video etc.

Written : Letters, circulars, memos, reports, notices, handbooks, manuals, booklets, magazines, bulletins. Email etc.

Visual: Newsreel, film, video, play, posters, pictures, boards etc.

Informal : Casual or incidental talk, meetings etc.

Barriers to Communication:

Despite of growth in communication system and modern electronic media, it may fail due to following barriers or obstacles.

1. Incomplete, ambiguous or badly expressed message.
2. Absence of clarity of thought.
3. Absence of brevity and exactness, unwanted length, words, repetitions, over-elaboration etc.
4. Timeliness i.e. the message does not reach in time.
5. Lack of attention by the receivers.
6. Organisational barrier - Scalar chain of command, filtering of message, discouragement to informal communication, excessive control etc.

7. Status barrier - Subordinate has fear to report everything to superior and may hide unpleasant facts.

8. Perceptual barrier - Receiver may pay attention only on that part where he has interest or liking and may underrate or filter the message.

9. Information overload - Due to overload work, managers may ignore some message, may forget to inform some people or may send incomplete message.

10. Premature evaluation - The receiver evaluates the message before getting complete information i.e. he derives premature conclusion.

11. Channel distortion - Physical, Mechanical or electronic disturbance or mistransmission due to channel distortion.

12. Improper order of information.

13. Improper selection of medium.

14. Emotional or sentimental messages.

15. Change of meaning during transmission.

16. Unwanted assumptions either by sender or

Essentials of Effective Communication :

Rules, principles or guidelines of effective communication or the measures to overcome its barriers are as under:

1. Message should be clear, complete, unambiguous and expressed properly.
2. Information should be in proper order/sequence.
3. Medium should be proper and effective.
4. Channel should be sound and undistorted.
5. Clarity - There should be clarity of thought.
6. Brevity - Message should be brief, precise and perfect. Meaningless words, repetitions, and excessive details should be avoided.
7. Timeliness - Message should reach in time.
8. Compassion - Sender should be aware of level of understanding and background of the receiver.
9. Integrity - Message must be consistent with objectives, policies and programmes. Action and behaviour of the sender should support his message.
10. Feedback - There should be follow up action (if necessary) to get feedback.
11. Careful listening by the receiver is necessary.
12. Strategic use of grapevine - The sender should try to fill up gaps in formal communication by strategic use of informal channel.
13. Create a climate of faith, trust and good human relations to make the communication effective and respectful.
14. Communication should be purposeful, at propel speed, sound and with synchronising.
15. Line of communication (reporting) should be clear.
16. Evaluation of communication system is useful for improvement.

Two-way communication :

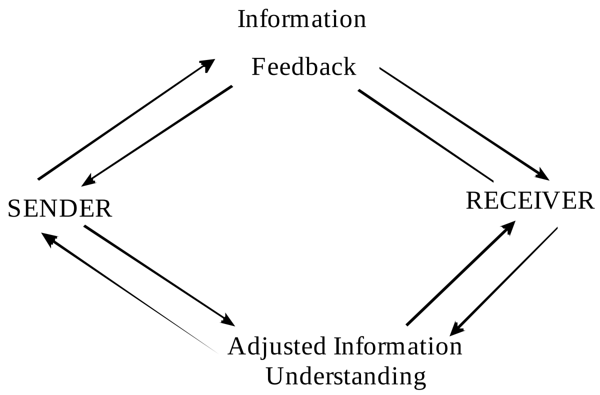

Fig. 6.13 Process of two-way communication

First a sender passes information to a receiver. He then gives feedback to the sender. If it is not as per expectation (correct),, the sender supplies adjusted information to the receiver. Then clear understanding takes place between them and in both the ways. Thus two-way communication (with correct feedback) is the effective communication. See Fig. 6.13

Ask the audience whether they have understood what you have explained. Get their feedback point or topic wise and then proceed further. One way transmission may go overhead. Therefore involve the listeners, ask questions, opinions and make the atmosphere live. First assess the needs, concerns, problems, age-group, levels of knowledge and experience of the participants and select the media and method accordingly. Effective listening steps are sensing, interpreting, evaluating and responding (feed back).

Group discussion, practical, assignment etc. are good programmes of two-way communication.

In two-way communication feedback is required which is not possible without good listening. Factors of good listening are :

1. Stop talking and thinking other subject.
2. Emphasize.
3. Maintain eye-contact.
4. Share responsibility for communication and
5. Clarify and interrogate if not understood. Two way communication is a key of success.

Communication and Group Dynamics :

Keith Davis defines "Group Dynamics" as the social process by which people interact face to face in small groups.

Group dynamics is the study of forces operating within a group. It is the study of field that deals with (1) Interactions and forces between group members in a social situation (2) The nature and development of small groups (3) Interactions among members and inter group behaviour (4) How a group should be organised and operated and (5) Nature, Structure and processes of a group, and their influence on the behaviour and performance of group members.

The assumptions underlying the study of group dynamics are as under:

1. Groups are inevitable and ubiquitous.
2. Groups can produce both good and bad consequences.
3. Desirable consequences from groups can be obtained through correct understanding of groups and their functioning.

4. Groups mobilise powerful sources that produce effects of utmost importance to individuals.

Kurt Lewin is considered to be the founder of group dynamics principle in management.

Group formation is a natural process everywhere, at home and at all work places. In industry the groups of workers does exist. By effective communication they should be motivated for safety. Instead of breaking their internal strength and informal relationship, it should be diverted to achieve organisational goals. Group training programme, group tour, group committee, group participation, group incentive and group targets can be organised by appropriate channels and tools of communication. Utmost care is required while addressing a group. Their dynamic strength should be well assessed and moulded by communication as desired.

Barry M. Staw suggests following steps to utilize groups to enhance satisfaction and performance :

1. Organising work around intact groups.
2. Having groups charged with selection, training and rewarding of members.
3. Using groups to enforce strong norms for on-thejob and off-the-job group behaviour.
4. Distributing resources on a group rather than on individual basis, and
5. Allowing and perhaps even promoting inter group rivalry (competition) so as to build within group solidarity.

The groups perform four functions of (1) Socialising the new employees (2) Getting the work done (3) Decision making and (4) Control measures.

Group dynamics states following characteristics of a group :

1. **Structure** - Each member occupies a position in the group depending on his status, power, experience, aggressiveness etc. Leadership is a special status.
2. **Roles** - Depending on position, the members perform three types of roles : expected role, perceived role and enacted role.
3. **Norms** - mean prescriptions for acceptable behaviour determined by the group.
4. **Informal managerial roles** - Managers can perform three types of roles (1) Interpersonal ' roles as a figurehead, leader and liaison officer (2) Informational roles as disseminator, monitor and spokesperson (3) Decisional roles as entrepreneur, disturbance handler, resource allocator and negotiator (Henry Mintzberg).
5. **Informal communication system** - or grapevine communications in all directions should be utilised to attain objectives.

Supervisors' good behaviour with their workers, informal relations and taking interest in their personal matters and paying constant attention for their individual growth, give desired results. Such behaviour is much more useful to make the workers safety Oriented. Sympathetic and fatherly behaviour is the best form of communication. Group dynamics should not disintegrate the organisation, rather it should strengthen integration. Art of communication should be developed for this purpose by giving special training to the superiors.

6.3.7 Controlling for Safety :

To complete the management cycle it is important to know about the function of controlling after knowing about planning, organising, staffing and directing.

Definitions:

1. **Koontz and ODonnell :** Managerial control implies the measurement of accomplishment against the standard and the correction of deviations to assure attainment of objectives according to plans.

2. **Robert N. Anthony :** Management control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of an organisation's objectives.

3. **Dr. George Terry :** Control is determining what is being accomplished, that is evaluating the performance and if necessary, applying corrective measures so that the performance takes place according to plans.

4. **Mary Gushing Niles :** Where planning sets the course, control observes deviations from the course and initiates action to return to the chosen or to an appropriately changed one.

5. **Peter F. Drucker :** Control maintains the equilibrium between ends and means, output and effort.

6. **Haynes and Massie :** Fundamentally Controlling is any process that guides activity towards some predetermined goal. The essence of the concept is in determining whether the activity is achieving the desired results.

7. **Henry Fayol :** In an undertaking, control consists in verifying whether everything occurs in conformity with the plan adopted, the instructions issued and principles established. It has for object to point out weaknesses and errors in order to rectify them and prevent recurrence. It operates on everything; people and actions.

8. **Hicks and Gullet :** Controlling is the process by which management sees if what did happen was what was supposed to happen. If not, necessary adjustments are made.

Thus controlling is aimed at (1) monitoring the outcome of activities (2) reviewing feedback about this outcome and (3) if necessary, take corrective action to achieve the outcome according to the plan.

Control function is closely connected to planning. It can be said an effective counterpart to planning.

Using these definitions, controlling for safety can be defined as "a process that verifies and guides activities towards predetermined (planned) safety goals and takes necessary action, if required, to achieve the goals."

Characteristics: Main characteristics (nature) of control are that it is (1) a system (2-) universal (3) a continuous process (4) forward looking (5) an influence process and (6) involving measurement.

Need (Purpose) : Its main purpose are (1) to measure progress (2) to uncover deviations or change, delegation, mistakes, complexity etc., and (3) to indicate corrective action.

Importance (benefits) : It offers (1) Guide to operations (2) Policy verification (3) Managerial accountability (4) Employee morale (5) Psychological pressure and (6) Co-ordination in action.

Types (Kinds) : Controls are of three kinds (1) Feedback control (2) Concurrent control and (3) Feed forward control.

Areas of Control: They are over (1) personnel (2) performance of production (with safety) (3) Finance and (4) Morale.

Steps (Elements) of Control Process : They are (1) Establishment of standards - qualitative and quantitative (2) Measurement of performance (3) Comparing performance with standards (4) Analysis of Deviations and (5) Taking corrective action.

Requirements of Effective Control System : The essentials are that the control systenn should be (1) Simple and easily understandable (2) Flexible and not rigid (3) Objective and need base (4) Forward looking (5) Prompt (6) Strategic point control (7) Motivating (8) Suggestive (9)-Economical and (10) Less time consuming.

Control Techniques: They include (1) Breakeven-analysis (2) PERT and CPM (3) Budgetary control (4) Zero based budgeting (5) Management Information System (MIS) and (6) Controlling or Monitoring by Safety Standards.

Controlling by Safety Standards:

This is an indirect way of controlling and improving safety standard of the company. Control by statutory provisions (See next Part 6.3.8) or standards are the first and legal requirement. In addition to this or in absence of this, national and international standards of safety should be followed. IS:14489 on Occupational Health and Safety-audit, OHSAS 18001 on Occupational Health and Safety Assessment Series, and ILO and EPA standards are available.

See Part 1.17 of Chapter-19.

If such standards are followed, they can help us in improving our safety standard (status) and recognition in the world market. Management control techniques should consider this aspect at the appropriate stage of the company.

For details of these standards, their document should be referred. Consultants are also available for guidance and preparation to get such standards.

Management by Exception (MBE):

It is a system or principle of managerial control based on the belief that effort of controlling everything results in controlling nothing and therefore there is no need to report performance within the permissible limits (i.e. acceptable deviations from the standards), but only exceptional (significant or major) deviation from standards should be reported to the management.

Benefits of this system are:

1. It saves time of Manager as they have to focus on exceptional matters. Routine problems are left to subordinates.
2. Managers can well concentrate on major problems .resulting in better utilisation of their talents and energy.
3. It facilitates delegation of authority for less important matters. This increases span o control and leads to motivation and development of subordinates.
4. It separates more and less important matters and tends managers to use knowledge of trends, history and available business data.
5. It keeps management alert to opportunities and threats by identifying critical problems.

6. It provides better yardsticks for judging results. It is helpful in objective performance appraisal

Management by Objectives (MBO) :

This concept was first given by Alfred Slown in 1950 but Peter Drucker popularised it in 1954 in his book 'The Practice of Management'.

This approach is also known as management by results, goal management, performance management and accountability management.

It is a system of management where (i) goals for the business as a whole are set and (ii) managers and staff members at every organisational level are actively involved in goal setting. The idea is that when employees are involved in goal setting for them, they will put their heart to achieve them.

Definitions:

1. **Peter Drucker -** Business performance require that each job be directed towards the objective of the whole business.

2. **George Odiorne** - It is a process whereby the superior and subordinate managers of an organisation jointly identify its common goals, define each individual's major areas of responsibility in terms of result expected of him and use these measures as guides for operating the unit and assessing the contribution of each of its members.

3. **W. J. Reddin** -It is the establishment of objective areas and effectiveness standards ' for management positions and the periodic conversions of these into measurable time bound objectives linked vertically and horizontally with future planning.

4. **S. K. Chakravarty** -It is a result oriented, non-specialist, operational managerial process for the effective utilisation of the material, physical and human resources of the organisation, by integrating the individual with the organisation and the organisation with the environment.

Nature (characteristics) of MBO :

1. It is a system approach integrating all employees for goal setting and achievement.
2. It is a behaviourist approach where human element is recognised at each level.
3. It is democratic approach because it is participative.
4. It measures results with the standards prescribed and suggests corrective measures.
5. It focuses on goals of the individuals and the organisation.
6. It has autonomous control because employees are not controlled from outside but they themselves evaluate their performance in terms of predetermined goals and devise corrective measures if their performance is below the norms.
7. It boosts up employees' morale and motivation because they are called for participation.

Process (steps) of MBO : Steps in sequence are:

1. Set objectives of the organisation.
2. Set objectives of the departments.
3. Set objectives of the individuals.
4. Develop action plans.
5. Implement plans.
6. Take periodic reviews.
7. Appraise results.

8. Take corrective action for improvement.

Advantages of MBO : They are :

1. Better management.
2. Clarifies organisation.
3. Harmony of objectives.
4. Motivation.
5. Evaluation of results.
6. Development of managers.
7. Improvement in superior - subordinate relations.

Scope (limitations) of MBO:

1. Difficulty of introducing for reaching changes.
2. Difficulty in setting goals.
3. Too much emphasis on results.
4. Pressure on employees.
5. Too high expectations.
6. Neglect of some important goals.
7. Not useful for all.
8. Rigidity.

Requisites (preconditions) of MBO :

1. Setting real objectives.
2. Ends - means distinction.
3. Clarity of objectives.
4. Active support from all participants
5. Active support of top management.
6. Three elements that objectives should be - helpful in evaluating performance, measurable and convertible into targets.
7. Multiple objectives and sub-optimisation.
8. Displacement of objectives.
9. Quantitative cum qualitative objectives.
10. Receptivity.
11. Training for fulfilment of objectives.
12. The 'why' spirit (why cannot be obtained?)
13. Individual growth.
14. Study of environment and flexibility.
15. Provision of performance.

Role of MBO in Safety : The concept of MBO is much more useful in setting and achieving safety goals because it is a participative approach and safety being everybody's duty and everybody's target (goal) this approach is best fitting for safety management.

First safety goals for the whole organisation should be decided by the safety department. They may be:

1. Safety policy.
2. Some million man-hours work without accident.
3. Clean environment at all workplaces.
4. Productivity with safety.
5. Hazards detection and removal.

6. Maintenance of guards and safety devices.
7. Use of safety equipment.
8. Accident reporting, detailed investigation and record for cost and lesson.
9. Safety inspections and control techniques.
10. Safety committee, its objectives and functions.
11. Ergonomic improvements.
12. Occupational health & hygiene.
13. Compliance of statutory provisions.
14. Formation of other safety rules for specific works, SOPs and safety permit systems.
15. Induction, on-going and periodical safety programmes.

All departmental heads should be involved in above goal setting and they should be convinced for their need and importance. These goals may 'be distributed department wise if possible e.g. training for training department. Then each departmental head will hold meeting of his employees and involve them in setting goals for their department. Departmental supervisors will observe fulfilment of these goals and guide their employees. Each employee will be fully convinced for his individual role and importance for the organisation, need for safety for himself and his family, cause and consequence of accident and use of his knowledge, experience and expertise in finding and removing hazards.

Lastly the performance will be measured against standards or expectation, evaluated, reviewed and reset with the participation of employees involved.

Thus the process of participation by MBO can be practised for safety to achieve desired results with live support and active atmosphere.

All above principles of Management must be utilised from planning to controlling stages of all programmes pertaining to industrial safety, health and environment. Goals must be set for safe design, construction, operation, maintenance, waste disposal, training, fire, first aid, medical check-ups etc. and their achievement should be monitored.

6.3.8 Statutory Duties of the Management :

Many safety statutes (as mentioned in Chapters 27. & 28) provide general and specific liability, responsibility or legal duties or obligations of the management. Such duties under two Acts are stated below. For other duties. Chapter 27 and 28 should be referred:

Under the Factories Act & Rules :

1. Approval, licensing and registration of factories and notice of occupation as well as notice of appointment of a new manager. Construct and run the factory according to the plans approved and statutory provisions.

2. To provide good hygienic conditions in respect of cleanliness, disposal of wastes and effluents, ventilation and temperature, dust and fume, artificial humidifications, overcrowding, lighting, drinking water, latrines, urinals and spittoons.

3. By sections 7A and 7B, general duties of occupiers, manufacturers etc. are imposed to ensure the health, safety and welfare at work of all workers in the factory. Plant and systems without risks, safety in use, handling, storage and transport of materials; information, instruction, training and supervision for the health and safety of all workers, safe places, means of access and conditions, provision, maintenance and monitoring of safe working environment and written statement of safety policy are necessary. An article is expected to be designed and constructed as to be safe and without risks. Safety instructions shall be supplied and followed.

4. Strict and absolute responsibility for safety is described for fencing of machinery, work on or near machinery in motion, employment on dangerous machines, striking gear and devices for cutting off power, self-acting machines, casing of new machinery, work near cotton openers, hoists and lifts, lifting machines, revolving machinery, pressure plant, floors, stairs and means of access, pits, sumps, openings in floors etc., excessive weights, protection of eyes, precautions against dangerous fumes, use of portable electric light, explosive or inflammable dust, gas etc., precautions in case of fire, safety of buildings and machinery and provision of safety officers. Various rules are prescribed under these provisions for textile, cotton ginning, wood working, rubber mills, centrifugal machines, power presses, shears, slitters etc. and some 27 types of dangerous operations and hazardous processes. (Rule 102 GFR).

5. By insertion of new sections 41 B and 41 C specific responsibility of the occupier in relation to hazardous processes (defined by section 2 (cb) and listed under the First Schedule) is imposed. This requires disclosure of information regarding dangers and health hazards, measures to overcome them, policy statement, on-site emergency plan and disaster control plan, publicising to workers and public, medical records of the workers and appointment of qualified and experienced persons to supervise handling of hazardous substances.

6. Provision and maintenance of various welfare facilities for washing, storing and drying clothing, sitting, first aid, canteens, shelters, rest. rooms and lunch rooms, creches, and Welfare Officers.

7. Duties for observing working hours, employment of young persons and women, annual leave with wages to workers, notice of accidents, dangerous occurrences and disease maintenance of various statutory forms, records and registers and supplying identity cards, leave cards, safety policy etc. to workers are also prescribed.

The Chief Adviser, Factories, Ministry of Labour Govt. of India, New Delhi, explains responsibility of occupiers under the Factories Act, 1948 in the following words:

"The responsibility for safety matters is -placed squarely on the shoulder of the occupier. He must comply with the safety provisions of the Act without waiting for an Inspector to visit and give instructions for what ought to be done. Unless the employer undertakes this duty, there are no. means of ensuring that this important provision will be observed. If, he shows himself determined to secure the use and maintenance of guards, he can effect this object. It is a very important point for the occupier to note, the requirements of the Act are absolute and are in no way dependent upon previous notice or warning from the Inspector'".

See Part 5 of Chapter-27 also.

Under the Environment (Protection) Act 1986:

1. Persons carrying on industrial operations etc. shall not allow emission or discharge of environmental pollutants in excess of the standards.
2. Persons handling hazardous substances shall comply with safeguards prescribed.
3. The occupier shall furnish information to authorities, allow their entry, inspection and sample testing.

Similarly, under other Safety Acts and Rules, I numbers of statutory duties are prescribed for ' management.

6.3.9 Overview of Safety Activities :

As explained in part 6.3.1 above, six functions of a scientific management reveals that safety can best be executed by a good management only and this is possible by constant over viewing of safety activities by the management.

What should be overviewed? Good planning of safety activities and statutory duties described in part 6.3.8 above, best organisational structure and staffing for it and constant direction, control -and coordination for all safety activities are to be overviewed to implement and achieve the desired safety targets.

6.3.10 Division of Responsibilities :

No management can succeed without distribution of responsibility at different levels or lines and proceeding through all such levels.

The words "responsibility", "accountability" and "authority" are used side by side creating confusion. Their deference is as follows.

Responsibility is a duty or activity assigned to a given position (s). It comes with authority. It requires answering for activities and results for targets.

Accountability is an active measurement by management to ensure compliance with its intentions.

Authority is the right use of power. Responsibility and authority should match with each other. We cannot hold a person responsible for an act unless he is properly authorised for that.

Duties and authority can be delegated but not the responsibility. A supervisor is always responsible for the actions of his subordinates and cannot escape from his responsibility by delegation.

It is accepted by good management that (1) Safety is a line management responsibility (2) Management should formulate safety accountability. The line of responsibility starts from the top executives.

Safety Responsibilities of Directors and Senior Management:

1. Legally and otherwise, top management is responsible for safe mechanical, physical and all working conditions created by them and under their control.

2. Because of its ability and opportunity it is also responsible for preventing unsafe actions of its work people.

3. By proper selection, training, instruction and supervision the top management should carry out above functions.

4. The occupier or the director so notified are responsible for compliance or breach of all statutory duties and liabilities explained in part 6.3.8 above. Not only the legal, it is their financial and human responsibility also.

5. Line managers have to carry out the safety policy approved by the board. They should promote and encourage awareness and willing acceptance of importance of safety among their staff.

6. Senior Managers have a similar responsibility for safety as for productive output and should ensure that this responsibility is accepted and shared throughout all supervisory levels. They must provide personal leadership in carrying out the policy, in participating in safety committees, in

introducing programmes, considering all accident investigations and setting a personal example in observation of safety regulations in their day to day work. They should also keep the board informed of the progress in implementing the policy, of supplying data on safety for the guidance of the board and making recommendations necessary for improving safety standards. They should recognise efforts of the staff who seek to improve safety. They should also be ready to take, any disciplinary action for breach of safety duty of the company's safety regulation.

Roles of others are explained in Part 6 to 8.

6.3.11 Location of Safety Functions :

After dividing the responsibilities up to supervisor's level it is necessary to fix the location of safety functions. Area jurisdiction of plant, department, shop, section should be decided and distributed along with the responsibilities. Who will carry out what function, where, who will report to whom, where the tools, equipment, records, registers lie, who will inspect, who will carry out job safety analysis, hazard analysis, HAZOP study, training and teaching etc. must be decided for smooth direction and co-ordination. They all should have common awareness for insisting to provide guards, wear safety equipment and to follow safe practices.

6.4 Safety and Purchasing Policy :

This is a 'planning' function of a management.

Definitions of Policy:

- **Koontz and O'Donnell** - Policies are general statements of understandings which guide or channel thinking in decision making of subordinates.

- **Dalton McFarland** - Policies are planned expressions of the company's official attitudes towards the range of behaviour within which it will permit or desire its employees to act.

Policy may be express or implied, verbal or written. Mostly it is in a short document form in writing. Objectives indicate destination and policy provides its route. Policy is the basic guidelines of attitudes, intentions, commitments or determination of the top management telling employees and the public its broad objectives and means to achieve them.

Types of Policies: They are classified as basic, general or departmental policies, production policy, sales policy, purchasing policy, accounting policy, marketing policy, finance policy, personnel policy, safety/health or environment policy, imposed policy, appealed policy, originated policy, opportunism policy (in politics and military), restrictive or permissive policy '(nature), written or implied policy etc.

Safety Policy is statutorily required u/s 7A(3) and 41B(2) of the Factories Act, 1948 and its details arc prescribed u/r 12-C and 68-0 of the Gujarat Factories Rules, 1963. For details see Part 6.4 of this Chapter - 'Safety .and Purchasing Policy '.

Need and Importance of Polities : They

1. Operationalise objectives.
2. Save time and effort.
3. Facilitate delegation of authority.
4. Speed up decision making.
5. Facilitate administrative control.

Characteristics of a sound policy (Principles of Policy Making): It should be:

1. It is based on objectives and should indicate how to attain them.
2. Clear, definite, explicit, precise and easily understandable.
3. Indicative of criteria limits and yardsticks for action.
4. Stable as well as flexible.
5. Planned development.
6. With norms of ethical behaviour and legal standards.
7. Just, fair and equitable to internal as well as external groups.
8. Communicated to people for implementation and
9. Reviewed and periodically revised to keep upto-date.

Steps in Policy Formulation :

1. Define policy area.
2. Identify policy alternatives.
3. Evaluate policy alternatives.
4. Select the best alternative.
5. Make policy document (if more details are required then policy manual). Follow statutory guidelines.
6. Communicate for implementation.
7. See its application into operational plans and all activities.
8. Review and revise to keep it up-to-date.

Factors influencing Policy Making : They are :

1. Values and beliefs of the top management.
2. Objectives (goals).
3. Prevailing techniques.
4. Availability of finance.
5. Employee relations.
6. Effects on public.
7. Policies of competitors.
8. Government rules and control (legality).
9. General business environment.
10. Level of prices.
11. Public attitudes and behaviour

The first step or objective of any safety management is to formulate its clear safety policy. It should be in consultation with the Safety Department, in writing, and should be updated as requirement from time to time. Now this is statutorily required under sections 7A(3) and 41B (2) of the Factories Act.

Content of Safety Policy :

As per rule 12-C and 68-0, of the Gujarat Factories Rules, 1969, safety policy should contain –

1. Commitment of the top management to health, safety and environment and compliance of the statutory requirements.
2. Organisational set-up to carry out the policy.
3. Arrangements to make the policy effective.
4. Arrangements for involving workers.
5. Consideration of health and safety performance for career advancement.

6. Fixing responsibilities of contractors, subcontractors, transporters and other agencies entering the premises.
7. Declaring health and safety performance of the factory in its Annual Report.
8. Techniques and methods viz. safety audit, risk assessment, at an interval of 2 years, on the status of healthy safety and environment and taking remedial measures.
9. Arrangements for informing, educating and training workers and the public where required.

A copy of the policy shall be given to authorities, workers, contract workers, apprentices, transport workers, suppliers etc. It shall be displayed at conspicuous places. It shall be revised whenever any expansion, modification, use of new substance or ; articles affect the health and safety of persons at work.

Model Drafts:

Health and Safety Policy are given below. Though these drafts do not contain all nine items mentioned above, they are useful in drafting the safety policy. Guidelines of statutory rules should be included in the draft.

Draft-1 :

This (name) company recognises the importance of safety for all its employees and the general public. It will be our endeavour to decrease environmental loads, including noise, through effective application of available technical measures.

The company accepts this as one of the prime responsibilities and to achieve the above policy, the company adopts the following principles.

1. Matters concerning safety, health and environmental protection will have squal standing in our objectives to perform the business efficiently. These aspects will duly be considered during projects, planning and decision-making.

2. All the statutory regulations on health, safety and environmental protection will always be complied with. Besides the company will extend fullest co-operation to public agencies like Fire Brigade, the Collectorate, Police, in combating any off-site emergency. The company will maintain its On-Site Emergency Action Plan to a high degree of preparedness. In case of any emergency endangering lives of the people, safety and health protection will have the highest priority.

3. The plants, equipment, systems and working conditions will be provided and maintained to be safe and without risk to the health of all the employees, contractor's workers, public and the environment.

4. Safety, Health and Environmental protection is a collective responsibility. Every employee needs to contribute to the best of his ability. The contribution thus made shall be, one amongst other factors, the criteria for assessing the performance and potential growth.

5. Ensuring safety, health and environmental protection is the responsibility of the line functions. Safety and Environmental Protection Department will supplement the line functions as advisor.

6. The specific responsibilities will be clearly defined in the safety concept of the company.

7. Every supervisor , manager and specialist must update their knowledge on the applicable guidelines and apply them in their functions as an ongoing programme.

8. Necessary information, instructions and training programmes and safety publicity aids will be developed for inculcating safety consciousness amongst the employees and to enable them to perform their duties in a safe manner including contract employees and transporters.

9. Internal safety audit reports will be dealt as one of the most useful tools for the technical management priorities.

10. It will be our constant endeavour to make the technology environmentally-friendly and minimise the outflow of wastes.

Draft-2:

It is the policy of this (name) company to :

1. Provide and maintain, so far as is reasonably practicable, plant, equipment, systems and working conditions which are safe and without risk to the health of all employees, visitors, contractors and the public and which avoid damage to property and adverse impact on the environment;

2. Protect all employees from exposure to any substance or activity which may be hazardous to health by providing suitable control measures based on assessment of the risks and recommendations made through periodical safety audits;

3. Provide information, instruction, training and supervision for all employees to enable them to carry out their duties and responsibilities in a safe and effective way;

4. Develop and maintain appropriate emergency response procedures, contingency plans and resources commensurate with the risks to business activities.

5. Provide an effective occupational health and hygiene programme.

6. Take full account of health, safety and loss prevention considerations in projects, planning and decision making;

7. Treat local laws and regulaticins on health and safety as minimum standards to be improved upon wherever reasonably practicable;

8. Actively encourage the involvement of employees in the promotion of health and safety;

9. Encourage employees to accept individual ' responsibility for their own health and safety and for that of their colleagues, and to cooperate fully with company management in maintaining and improving health and safety standards;

Draft - 3

It is the policy of this Company (Name) to conduct its activities in a manner which ensures the healthful work environment and safety of its employees.

At all Company locations Local Management has the responsibility to ensure that all processes, equipment and facilities are designed, constructed, operated and maintained in a safe condition. It is also their responsibility to adhere to all applicable national, state and local government regulations. Cost considerations or the demands of production and operations, must not overshadow safety considerations.

It is the obligation of every employee to know and follow our safety rules and procedures, to teach what we know to others; to recognise unsafe acts and situations; to warn others of unsafe conditions; to react positively to emergency situations; to report promptly hazardous or unsafe practices and conditions to 'concerned Department Head; to protect the company property from loss or accidents and to perform his or her tasks to ensure the health and safety of themselves, fellow employees and the neighbouring communities.

Our Company is committed to achieving high standards for your personal safety and healthful work environment, as well as the safety of the communities where we operate. This type of safe and healthful work environment will be the result of complete cooperation, positive, prompt actions and a sincere commitment from all employees.

Draft-4

"Safely of person overrides all the production targets" - is the Health, Safety and Environment Policy of (Name of the Company).

To attain this, the Health,' Safety and Environment in the plants are safeguarded by the provision of:

1. Properly designed plants and machinery.
2. Effective use of safe working procedures, tools and equipment.
3. Meeting in all respects the applicable statutory requirements.
4. Clearly defined procedures for inspection, operation and emergency shutdown and their updation.
5. Continuous, systematic and micro level auditing - internal as well as external - of work procedures and practices.
6. Continuous and systematic education of Company's, Contractors' and Transporters' personnel for observing safe work practices.
7. A detailed investigation of all incidents including the minor ones and near-miss incidents followed by recommendations to avoid recurrence.
8. Analyse the findings or investigations of accidents in similar industry and take steps to prevent such accidents in the plants.
9. Keep abreast with the latest international codes, standards and practices.
10. Continuous monitoring of plant and ambient environment as well as of various effluents liquid, gas and solid - to maintain a clean and safe environment in and around the plants. .
11. Pre-employment and periodic medical check-ups of employees for early identification of occupational health hazards.

The policy so made should be circulated to top, middle and supervisory management and also to shop floor workers, apprentices and new entrants. Its enforcement should be effective and 'the top management must take full interest in it. It should be re-circulated at appropriate interval to redirect the attention.

Purchasing policy:

This should always consider safety aspect while placing order for machinery, vessels, tools, equipment, materials etc. A safety man should be charged with responsibility of checking plans and specifications of the items to be purchased. An approved list of items can be prepared for purchase department. The head of the department where the item is to be used should be consulted for his experience and requirement. Purchase orders should always specify that machinery be fully safeguarded and complying fully with the statutory requirements. Such type of purchase inquiry will encourage the machinery manufacturer or supplier to co-operate gladly with purchasers to solve their safety problems and to supply built-in-guards. Personal protective equipment should be purchased of good quality, reliability and standards and after consultation with the supervisor and the workers concerned. Inadequate protective equipment is worse than none, because it gives a wrong impression of safety.

The safety department should have good liaison with engineering and purchasing department. It should devise and enlist the safety standards that will guide the purchasing departments. Generally purchase people are cost conscious. They may buy the cheaper tools and equipment. Then they should be convinced of accident costs due to that. Safe mode of transport and handling material should also be suggested. Various codes, standards and statutory requirements should be considered. The purchase man should understand the hazard, accidents caused in past, legal or safety requirements, cost due to inferior quality, location or use of the machine and equipment etc. from the safety man.

6.5 Role of the Supervisors or Foremen:

A Supervisor or foreman (or forewoman) is a chief worker in charge of a group of workers and who exercises such control over them as delegated to him (her) by the management.

A supervisor is an important link or key-man between management and the workers. He is constant on the shop floor, more close to the workers, devoting more time in close observation of performance. He converts management's policy into action with the cooperation of workers. Management looks him as a shop floor manager in-charge of men, machines and materials and responsible for men's behaviours on jobs. Workers look him as their representative for the management. Workers like to give their opinions or complaints through supervisors. Management likes to influence workers' behaviour through supervisor and the workers like to gain first hand knowledge through supervisor. Management achieves the production targets through supervisor and workers achieve their targets, resources and facilities through supervisor. Therefore good supervisors are essential for effective implementation of management policy (including safety policy) on the shop floor.

A good supervisor performs the following functions:

1. Assurance of quality production within specified time and cost. He has to see quality, quantity, efficiency and effectiveness all at a time. This requires high skill.

2. Constant watch over safe conditions and actions for accident less production. He has to teach safety through his behaviour. His attitude is first reflected.

3. He has to see continuity in production. Therefore he manages to repair the machine and restart the job at the earliest possible.

4. He helps the workers in training them for their fobs and in solving their problems. He is useful in carrying out job safety analysis and on the job training.

5. He ensures safety through four major areas (1) Working machine/equipment and the job (2) Work area/environment or surrounding (3) Work methods, SOPs and actions and (4)- Work attitudes. For this purpose he inspects machine condition, job condition, surrounding situations, working environment, methods and worker's attitudes and tries to remove any defect if noticed. Checklist for this purpose may be very long but his eye should be the checklist. He establishes work methods, assigns jobs to persons, gives job instruction and maintains man-machine reaction safe.

6. For matter out of his control, he will immediately report to his higher officer. Meanwhile he makes temporary safety arrangements.

7. He pays attention on good maintenance of machines, materials, tools, etc. and also on good housekeeping and good health of the workers.

8. He reports all accidents and defects to the management and carries out their investigation for the purpose of stopping its recurrence.

9. He supplies proper protective equipment to workers and persuade to use them.

10. He observes and understands worker's difficulties. He observes physiological and psychological factors such as body movement, reaching-walking time and distance, weight, workload, environment, boredom, monotony and tries to find the solutions.

11. He has to carry out compliance of safety measures suggested by Safety Department, Factory Inspectorate and other authorities. Here he needs support from the management as well as workers.

12. He has to fill requisite production report, performance report, safety report and other records required. This requires his manifold personality.

Thus sympathetic and intelligent support of the able supervisor is essential to any safety programme. Proper training of supervisors in accident prevention is essential.

The status, responsibility and the degree of supervision of a supervisor varies according to the size and type of the industry, number of workers under control, position in hierarchy and extent of authority delegated. In a small factory a supervisor may enjoy wide power while in a big one where safety officer and workers safely committee exist, his role becomes limited to that extent.

6.6 Role of the Workers :

Who are most exposed to hazards? Who are nearer to the unguarded machines? Who handle the hazardous chemicals? Who lift the heavy materials? Who .face the dangerous machines, hazardous processes, unsafe conditions, situations and environment? Who mostly lose the life or get injury in accidents? No doubt, they are the workers only. They are the first victim of any accident. They are the sufferers of pain and all ill effects of occupation. Their families also suffer the losses. Occupational diseases and poisoning, minor or major injuries first touch them, because they are nearer to machines, hazards and environment. Therefore they must realise that any accident prevention work is in their interest and will save their lives. If they understand this fact, they will understand the need of safety and their role to promote and maintain safety.

The management should bring above facts to the worker's knowledge by accident figures, costs, compensation and company losses. Trade unions of workers should also teach the workers their safety duty and safe ways of working. **Workers' role should be explained to them as follows;**

1. Safety is worker's well-being and in their own interest. Their actions should be based on this.
2. Before starting the work, they should check all guards, fencing, safety devices and equipment in proper order and should always follow the safe methods of working. It should be checked after the closure of work also.
3. If safety guards and personal protective equipment are not provided, they should demand it through their supervisor or safety department.
4. Surrounding place should be kept clean, safe and without obstruction. "Safe Production is the best Production" and "Good housekeeping is always essential" should be their habit.
5. Wrong habits at work should be left.
6. They should take part in Safety Committee as expected under section 41 G of the Factories Act.

7. It is their right and duty under section 41 H of the Factories Act to warn about imminent danger in hazardous processes and to inform the occupier/manager and also the Factory Inspector.

8. They should analyse their own mistakes and failures tending to hazards and accidents and shodid rectify them with the help of supervisor or safety department.

9. Temptation to earn more by working overtime causes health hazards. Hurry, worry, short-cuts, chance-taking, over speed and over confidence also contribute accident causes. A shortcut may cut short. Therefore they should be avoided.

10. Sections 97 and III of the Factories Act draw attention toward offences by workers and their obligations. They are supposed to comply with the provisions of this Act, Rules and orders made there under imposing any duty or liability on them, otherwise, they are punishable.' Such duties cast upon them are :

    (a) They shall not wilfully interfere wither misuse any appliance, convenience or other thing provided for the purpose of securing health, safety or welfare of workers.

    (b) They shall not wilfully and without reasonable cause do anything likely to endanger themselves or others.

    (c) They shall not wilfully neglect to make use of any appliance or other thing provided for the purpose of securing health or safety of the workers and

    (d) They shall not refuse to undergo medical examinations for their health and safety.

11. They are responsible to their employer for their safe conduct of their work and safe upkeep or maintenance of machines and equipment.

12. They should not unduly interfere with the work of fellow workers and similarly should not allow fellow workers to interfere with their work. They .will exercise due care and good judgement in preventing accidents.

13. They should give their knowledge and experience in safety to new workers for safe working.

14. Through safety committee or union they should suggest their views in formulating safety rules and regulations. Thus they should give their • share to participate in safety management.

15. **Safety Representatives:** Some senior, experienced and selected workers can be assigned responsibilities to help supervisor in his work and to develop safe work methods, keep watch and to report hazards, correct and warn co-workers if they are found committing unsafe acts or breach of safety rules and to develop safety interest and behaviour among others, investigate small accidents and thus to act as a safety assistant to the supervisors. Such safety representative can then be easily promoted as supervisors. They can also join worker's safety committee or the joint safety committee.

6.7 Role of the Trade Union

Generally a trade union is a combination o work-people for collective bargaining on pay and conditions of employment, though its activities have expanded with the passage of time. Unions first grew up in UK and Eastern Europe and now they exist in each country. International trade unions also exist. In demands of better service conditions they should insist for safe and healthy working conditions also.

At present we see the trade union's role as mostly opposing management, raising demands for wages and allowances and launching cases in Labour Courts and elsewhere. With a few exceptions, hardly they do any work of teaching or educating for safe work practices. It is desirable that whatever may be their other activities; they should help the management in the joint task of safety by playing the role as under:

1. Checking and demanding for safe place, tools, machines, equipment, working conditions and environment for work.
2. Training and insisting their members to use and maintain guards, safety devices, protective equipment and to follow safe work practices. They can run the teaching classes in their offices in addition to the training by the management.
3. Always helping in maintaining safety in running the plant and safe closure of the plant in case of emergency. They should take lead in executing on-site emergency plan and the disaster control plan under the guidance of the management. In the matter of safety all problems should be solved by co-operation. Safety is not a field for quarrel. Safety equipment and conditions must be demanded but sabotage or any act endangering safety of plant, machinery, workers and others should not be committed. A helpful approach should be followed.
4. Checking for physical workloads, working hours, odd shifts, welfare facilities and statutory requirements for health, safety and welfare of workers and bringing them to the notice of the management and the authorities.
5. Actively participating in all safety campaigns, safety-day-programmes, seminars, publicity and every type of motivational safety movement.
6. Urging both management and members to measure up their responsibilities to safety drive and fulfil their obligations to each other so as to supplement the efforts.
7. Deputing their members on worker's safety committee or joint safety committee.
8. Sending their members for safety courses, seminars, and training classes.

6.8 Role of the Competent Persons:

By the Gujarat Factories (Amendment) Rules, 1995, rule 2-A was added from 15.02.95, regarding competent persons for following types of testing, examination and certification.

1. Structural stability of a factory building.
2. Dangerous machines (Rule 57 names such machines).
3. Lifts and Hoists.
4. Lifting machines and tackles.
5. Pressure plants (vessels and piping u/r 61.)
6. Dangerous fumes.
7. Ship building, repairs and breaking.
8. Ventilation and exhaust system.
9. Every work of engineering construction i.e. any building, tank, silo, scaffold, platform, chimney, bridge, supporting structure, retaining work or any similar structure (Rule 3C).
10. Centrifugal machines (Rule 54, Sch.5)
11. Power presses and their safety devices, (Rule 54, Sch.6).
12. Thermic fluid heaters (Rule 68D)
13. Ovens and Dryers (Rule 68 G)
14. Ventilation system in Asbestos manufacturing (Rule 102, Sch.17).
15. Instruments, safety devices, plant & equipment in chemical works (Rule 102, Sch.19).
16. Carbon disulphide plant (Rule 102, Sch.22).
17. Foundry operations (Rule 102, Sch.26).

Role of a 'Competent Analyst' is prescribed for ship building, repairing and breaking u/r 68 H and that of a special competent person (in-house) for a solvent extraction plant u/r 102, Sch.21.

B.E. and M.Sc. degrees in respective branch, 7 to 10 years experience and necessary facilities (equipment) are prescribed for a person or institution to apply for certificate of competency. Powers of the Chief Inspector are also prescribed.

Role of such competent persons in promoting and maintaining safety is most important for the management. By rules it is prescribed to examine and certify:

Duties and functions of the competent persons should be as under :

1 He should be a master of his subject.

2. He should have full facility of workshop, equipment, instruments etc, required for various tests to be carried out Equipment for extra heavy load testing, tensile testing, non-destructive testing, wind velocity meter, speedo-meter, metal quality, composition and thickness detector, hardness tester, various gas detection equipment, O_2/N_2 and hydrocarbon detector, noise meter, gauges/gadgets for testing-hoists and lifts, ' facilities for heat treatment, hydraulic testing and testing of effectiveness of the extraction systems for dusts, fumes, gas, vapours etc. should be available with him.

3 He should have qualified and experienced technical persons who know the use of above equipment.

4. He should have a library of technical books, safety codes and standards (viz. 18:2825, ASME code etc.).

5. He should have prescribed forms and certificates readily available, preferably computerised.

6. He should maintain the copies of certificates given to his customers, party wise, date wise and section wise.

7. He should have records/registers for the names, addresses and phone numbers of his customers, schedule of testing dates and a system of advance intimation of due dates of next testing to his customers.

8. He must report to the Chief Inspector of Factories and local inspector wherever it is statutorily required to do so.

9. He should keep a list of suppliers of safety standards and codes, safety devices, equipment, instruments etc.

10. He should guide properly and with details to the customers and the authorities as an expert and should be prompt for follow up action.

See Part 3.9 of Chapter-15 also.

6.9 Role of the Safety Specialists (Consultants or Professionals) :

The safety specialist or consultant is an outside expert agency whose services are hired by the management to guide or advise them on the matters of safety.

The safety specialist may be (a) An engineer to carry out tests and to suggest engineering controls (b) An occupational hygienist to suggest hygiene points (c) An occupational doctor to check, report and treat workers and work places for occupational health and (d) An industrial psychologist to study and guide for the psychological problems of the workers.

Having much experience and the latest knowledge on safety subjects, his role is important He can design and prepare plant layout, suggest safety guards and devices, protective equipment, safe working conditions, actions, methods, procedures, instruments, technique and all matters of statutory requirements. He can investigate accidents, analyse hazards and risks and furnish report of remedial measures. He may carry out special (e.g. Non statutory) tests for pressure vessels, lifting machines, illumination, noise, vibration, toxic exposure, utility services, control equipment and instruments and all safety aspects needed by the management. Thus he has got a vast and specialised field requiring high qualification, experience, insight and good power of observation, inspection, investigation and report-writing.

He recommends improvements, takes part in training and educating supervisors and workers, participates in safety meetings and seminars, acts as coordinator of safety work and as liaison officer with top management. Such safety specialists are rarely available, though it is a need of time. Experienced factory inspectors, safety officers and engineers can play good role of such safety specialist or consultant.

The safety professional's challenge is to accelerate and sustain use of safety techniques with the help of line managers. Therefore any safety professional must promote safety in diverse ways thereby getting the required attention and impact for the function within the organisation.

Some of .the ways in which can be reached to practising managers are : setting up experience sharing forums, projecting safety statistics to top management, empathising with "safety users" to get the right appliances, dissemination of accident stories, companywide consistent awareness programmes by use of multimedia and video, continuing education and use of positive reinforces to promote safe behaviour. The way safety is internalised is limited only by the safety professional’s imagination. Because safety is common sense, it may be taken for granted, therefore, one needs to bring energy and creativity to reinforce safety concepts in employees.

7 SAFETYORGANISATIONS

7.1 Types and Objectives (Need) :

Safety organisations include industrial management described so far, the governments and their labour or safety departments and the voluntary organisations such as International Labour, Organisation, National Safety Council, Central Labour Institute, State Labour Institute (viz. Mahatma Gandhi Labour Institute, at Ahmedabad), Gujarat Safety Council, Safety Chapters, Loss Prevention Associations, Safety Specialist or Consultancy Services and Safety Associations.

There are occupational health organisation, World Health Organisation and many other national and international organisation working for health, safety and welfare of people.

The objectives may vary depending upon the object, area, scope, team or personnel structure, qualification and experience, goals or targets and capacities of above organisations. Major difference is their jurisdiction, limitation and specialisation of safety work.

Some common objectives are :

1. To promote and maintain safety in all walks of life viz. industrial safety, road safety, home It safety etc.
2. To suggest safety rules for statutory amendments.
3. To conduct safety studies and seminars on major hazards and to publish reports for guidance.
4. To educate and train people for safety.
5. To run special safety services such as for engineering controls, health and hygiene, industrial psychology, testing laboratories, workshops for guards, design and performance, training and education, and various safety programmes.
6. To publish safely bulletins, booklets, posters and literature for general safety awareness and increasing knowledge.
7. To conduct safety courses for safety officers, supervisors, inspectors, workers and management.
8. To conduct safety competitions and to give' safety awards for encouragement.
9. To give requisite guidance on special safety problems of industries, government, workers, unions and associations, and
10. To carry out safety surveys, analysis, inspections, accident investigations and specific work studies for the purpose of detecting, directing and removing hazards. More such objectives can be available from the written constitutions of such organisations.

7.2 Role of the Organisations:

Role of three organizations is explained below:

7.2.1 Industrial Organisation's Role :

Part 5.2 and 6.3 of this Chapter have already described general and safety management's role. Some more information is given below:

An industrial management tries to achieve maximum productivity by its efficient organisation. Similarly in the field of occupational health and safety, it should try to achieve the goals of safety by reducing accident frequency and severity rates and risks and hazards tending to accidents. It should organise and integrate all efforts involving everyone from top management to the shop-floor workers. For this purpose it should (1) make a definite safety policy statement (2) divide and assign responsibilities (3) describe staff and line functions and duties of safety departments, safety committee, safety officer, supervisors, workers and others, (4) organise safety programmes which include inspection, audit, analysis, investigations, evaluation etc. (5) review the programmes and policy and make them updated and most effective based on timely requirements.

Essential elements (objectives) of a safety organisation are:

1. Management leadership.
2. Assignment of leadership.
3. Maintenance of safe working conditions and actions.
4. Establishment of safety education and training centre involving active participation of workers and unions.
5. Accident record system and management information system (MIS) with all safety statistics and costing.
6. Medical and first aid facility and
7. Acceptance of personal responsibility by employees.

Division of responsibilities is already explained in Part 6.3.10 of this Chapter. One model set-up (structure) is explained there. But this is variable from industry to industry. In a big company the resident manager takes the responsibility to develop effective programme for accident prevention or total loss control. Plant Superintendents are responsible for maintaining safe working conditions and practices in the areas under their jurisdiction. Department Heads and Supervisors are responsible for accident prevention in their departments and foremen (below supervisor) are responsible for accident prevention in their crews or a team (group) under their control. The Safety Director delegated by the Resident Manager has the responsibility to provide advice, guidance and any aid needed by the plant people. He decides for selection of protective equipment and safety devices, planning and holding safety meetings, devising forms and registers for - safety training, inspection, audit, checklist, safety sampling, job safety analysis, hazard analysis and different safety studies, posters, notes, notices, first-aid-training, fire-fighting training, hygiene training, and arranging periodical safety programmes for safety awareness, maintaining safety records and registers, keeping in touch with new safety developments, coordinating efforts of management and workers and rehearsal of on-site and off-site emergency plans.

7.2.2 The Government's Role :

Role of the Government in promoting and implementing safety is vital, because when voluntary efforts do not succeed, it is only the force of law which actuates people to move according to the desire of the Government. This is true from the ancient time. Because the older saying vxzr% prqjks osnk% i'pkn~ l'kjks/kuq% conveys the same meaning that "O men, follow the knowledge of four Vedas which are kept ahead, otherwise there is a bow with arrows behind". This indicates the need or fear of legal punishment in case of infringement of rules. Thus the legal enforcement is the primary duty of any Government organization.

Various safety statutes are enacted by Central and State Governments and number of amendments is being added to it. It is the duty of the Government to publish afresh all such Acts and Rules as early as possible for the knowledge of all public. It is also the duty to employ inspectors to check the legal compliance of such rules and to guide the management and workers for smooth implementation of all safety provisions and to institute legal actions if needed. Vast powers are now given to officers to seek strict compliance including issue of prohibiting order to stop manufacturing till the compliance is achieved. Sections 9, 10, 39, 40, 40A, 40B, 41, 41A, 41B, 41C, 41D, 41E, 41F, 41G, 41H, 87, 87A, 88, 88A, 89, 90, 91, 91A and various penal provisions under Chapter-X of the Factories Act describe wide powers of factory inspectors. Such powers are also provided under different state wise Factories Rules. This is a volume in itself and may be referred for details.

Powers of the Government were added in the Factory Act in 1987 regarding constitution of Site Appraisal Committee, compulsory disclosure of information, specific responsibility in relation to hazardous processes, appointment of Inquiry Committee, permissible limits of exposure of chemical and toxic substances, worker's participation in safety management, right of workers to warn about imminent danger and power to prohibit employment on account of serious hazard. Similar safety powers of government authorities are also available under other safety statutes (See Chapter 27 and 28 for this purpose).

Detailed instructions are listed for Inspectors of Factories. Their General Duties in short are:

1. To promote and enforce the uniform observance by occupiers and workers of the legal provisions of the Act and Rules.

2. To supply information and advice to employers, workers and their association concerning the best methods of complying with the legal provisions and the means of securing the best possible working conditions.

3. To bring to the notice of the competent authorities any defects or abuses not specifically covered by existing legal provisions and

4. To carry out such other duties as may be allotted to them.

Role of friend, philosopher and guide is also expected from them.

7.2.3 Role of the Voluntary Organisations :

International Labour Organisation (ILO) at Geneva carries out various functions to back up national action in occupational safety and health as follows:

No.	National action	ILO action
1	Legislation.	Conventions, Recommendations & advice on the drafting of legislation.
2	Regulation	Model codes, codes of practice, technical advice.
3	Technical and medical inspection.	Manuals, guides, technical publications, the CIS services.
4	Activities by safety and health institutes, training and information of specialists.	Fellowships, courses, symposia, congresses, technical advice and co-operation, the CIS services.

5	Worker's education.	Seminars, publications, audio-visual aids, the CIS services.

Details of such activities of the ILO can be had from its various publication, (see Reference No.5 at the end of this Chapter).

Central Labour Institute at Sion, Bombay-22, also carries out similar activities in India. Its ILO observation runs as "Examples of active specialised occupational safety and health institutes in Asia are to be found in India whose Central and Regional Labour Institutes are among the best of their kind in the world".

Some activities of the CLI are: (1) Safety education and training including (a) One year Post Diploma course in Industrial Safety for safety officers (b) Training of Factories Inspectors (c) ILO/ARPLA/ CLI courses (d) Training of foreign nationals (e) Safety training of executives, supervisors, workers and trade union leaders (f) Mobile safety exhibition and (g) Films and posters, (2) Research activities including (a) National study of accidents in the sheet metal working machinery and their safety features (b) Study of accidents in ferrous foundries (c) Ventilation studies (d) Noise studies (e) Textile studies etc. and (3) Consultancy projects. (4) It publishes various reports and publication.

National Safety Council sitting in the same building (now shifted in a new building in Navi Mumbai)- carries out the similar nation wide safety activities including safety seminars, publication of "Industrial safety chronicle" and plenty of safety literature.

Gujarat Safety Council at Vadodara and **Gandhi Labour Institute** at Ahmedabad are the state level safety institutions carrying out the similar activities. The GLI follows the CLI pattern and also conducts Post Diploma Course in Industrial Safety, various safety studies and training of employers, employees and inspectors.

Safety, Health and Environment (SHE) Association established at Bharuch in Gujarat unites safety officers, doctors and environment officers and carries out regular safety programmes including safety publication.

See Part 13.1 of Chapter-5 for names & addresses of 30 such organisations.

8 SAFETY DEPARTMENT

8.1 Size, Status and Functions of the Safety Department:

In foregoing Part 6.3.1 and 6.3.3 of this Chapter hierarchy of Safety Department from the Safety Board to Safety Committee, their general and scientific functions and their division of responsibilities are described. This constitutes a Safety Department. Its size and function varies with the size, nature and type of the factory with varying style of designations. There may or may not be Safety Board and may or may not be Safety Director. It may be headed by a Safety Manager or Chief Safety Officer or Safety Officer or Safety Superintendent, and he may be directly reportable to the General Manager as a Head of the Safety Department.

A system of making safety manager reportable to Personnel Manager or Public Relations Manager of Chief Engineer or Production Manager is not proper and not desirable as it keeps his status below to them.

By qualification (engineer with special diploma in safety), experience and expectation of the most important responsibility of health and safety of the whole factory and surrounding and of manifold functions (described in following paras) his status is not at all lower than these officers and therefore he should be positioned as independent Head of the Safety Department directly reportable to the top executive of the company. Unless and until his status is not so recognised, we shall not get the full advantage of this department and it is not matching with the safety policy declaring safety as the most desirable and lover-riding management function. Statutorily also it is required so.

Thirty years have been passed to the insertion of section 40B (with effect from 26.10.1976) for the I requirement of "Safety Officers" under the Factories Act 1948 and twenty three years have been passed to the ' Gujarat Safety Officers Duties, Qualification and Conditions of Service Rules, 1983 (with effect form 1-12-1983), but still many companies hesitate to give such full recognition and status to the safety officers disappointing them and thus impeding safety.

There are many functions for safety department and it will soon be realised if any management will go through the subjects and contents of this book. The subjects of safety are many requiring many duties, systematic planning and daily performance of regular checking, monitoring and training of workers. Actually the Safety Department must be equipped with sufficient staff and assistants to the Safety Manager or Officer for his many fold functions and for promotional opportunities of the safety men at lower cadre in this I department.

Functions and duties of' Safety Officers are discussed in the next part.

8.2 Safety Officer :

8.2.1 Need of the Safety Officer:

1. The mankind has always felt an age-old and permanent need of a saviour. The concept of God, Head of family. Head of a group and Head of society or people for their safety and protection indicates the basic need of a safety officer in its widest concept. The God is the greatest safety officer for all of us.

2. **Statutory need** is the base of requirement of an industrial Safety Officer. They are as follows:

    (a) Section 40B of the Factories Act 1948, creating the post of safety officer since 26.10.1976.
    (b) Notification No. KHR-566/FAC-107736875-M-1 dated 17.09.1983. Labour and Employment Dept., Sachivalaya, Gandhinagar, first published the Gujarat Safety Officers Duties, Qualifications and Conditions of Service Rules 1983, under the Factories Act 1948.
    (c) Notification No. KHR-728-FAC-1077-36875M-l dated 28.11.1983, above department appointed 1-12-1983 to be a date for the aforesaid Rules to come into force.
    (d) By the Notification No. KHR-294-FAC1085-1-130-M (1) dated 23.04.1985, the Government of Gujarat recognised (1) Diploma in Industrial Safety awarded, by the Technical Examination Board, Govt. of Gujarat and (2) similar Diploma by the Director of Technical Education of the States of Maharashtra, Tamil Nadu, West Bengal and Uttar Pradesh for the purposes of the Rule 3(ii) i.e. requisite qualifications under the Rules published as mentioned in para (b) above.
    (e) By the Notification No. GHR-2005-124FAC-2005-M (3) dated 4-12-2005 of the same Department; the Govt. of Gujarat adds the degree of MIHS (Master of Industrial Hygiene and Safety) of Sardar Patel University as a qualifying degree to become a Safety Officer.
    (f) By the Notification No. KHR-529-FAC1077-36875-M (1) dated 19.12.1985 of the same department, the Govt. of Gujarat specified the number (need) of safety officers as below:

No. of workers	No. of Safety Officers
1000 to 1500	1
1501 to 3000	2
3001 to 4500	3

4501 & above	4

(g) By Notification No. KHR-2003-57-FAC2003-2872-M(3) dtd 28-5-2004 of the same Department, the Govt. of Gujarat specified that each Major Accident Hazard (MAH) installation employing 100 or more workers shall employ one Safety Officer.

For definition of 'MAH installation' see section-2(g) of the Chemical Accidents (EPPR) Rules 1996.

(h) The syllabus is also prescribed by the Technical Examination Board, Gujarat for one year full time or two years part time course of Post Diploma in Industrial Safety. *This book is written to meet the requirements of this prescribed course, but, it contains many additional materials also so that the whole book is most useful to industries, safety officers, safety engineers, factory inspectors, managers, supervisors, workers and tJie public.*

3. Safety is the most important aspect. It must be given prime importance. There should be an exclusive officer for it. That's the Safety Officer.
4. Accidents and injuries must be prevented. The human life must be saved. These are the basic needs. For this the Safety Officer is required.
5. The Safety Science is much developed and widened. It has included many branches, techniques and many safety devices. All this needs a Safety Officer.
6. Factory Inspector has to look after so many factories and manifold duties. He cannot pay daily attention to each factory.
   A Safety Officer is expected to be a Factory Inspector for his own factory. He will keep a constant Watch for the safety in his factory.
7. Now-a-days machines, equipment, control measures, processes, process parameters and hazards are increased. This has increased the need of a safety officer.
8. Now-a-days more and more systems are developed. Work planning and work system are given more importance. Safety is also a work as well as a system and there should be a man to maintain it. This man should be a Safety Officer.
9. Major accidents in the world (like Bhopal) have emphasised the need for safety officer in a big or hazardous factory.
10. Two questions always need attention:
    1. WHY accidents (industrial losses) take place?
    2. HOW they can be prevented?

    Q.1 explains the causation analysis
    Q.2 explains the prevention techniques and safe work practices.

For constantly thinking of these two questions, their replies and to implement the safety measures, a safety officer is a must.

11. Use of chemicals is tremendously increased. This brings many hazards, occupational diseases, poisoning and health problems. To identify, minimise and prevent these increasing chemical hazards, need for a qualified and skilled safety officer is increased.

12. For appraisal of statistical' safety data and planning based upon it, a safety officer is required.

8.2.2 Safety Officers' Rules and their Role:

Summary of these Rules along with its last amendment in December 2005 is given below.

Gujarat Safety Officers Duties, Qualifications and Conditions of Service Rules, 1983:

Qualifications:

Rule-3 requires that basic qualification of a Safety Officer should be a degree or diploma in industrial safety recognised by the State Govt. Degree of MIHS (Master of Industrial Hygiene and Safety) of Sardar Patel University, Gujarat has also been recognised since 14-12-2005. He should have adequate knowledge of Gujarati language. **Without safety qualification, appointment as a Safety Officer shall not be continued after two years.**

Rule 3A and 3B are added by the amendment dated 30-11-2005 regarding appointment of Safety Officer and its procedure. Occupier is required to appoint number of Safety Officers as notified by the State government within six months from such notification. Advertisement in two local news papers is necessary before the appointment of a Safety Officer. A committee will select such officer from the applicants. The appointment will be notified to the Director, Industrial Safety and Health.

Filling up of Vacancy:

Rule-4 - Every vacancy in the post of a Safety Officer shall be forthwith notified to the Chief Inspector and shall be filled up within 3 months. Status:

Rule-5 regarding conditions of service states that where the number of Safety Officers exceeds, one of them shall be designated as the Chief Safety Officer and shall have status higher than that of others. The Chief Safety Officer shall be in overall control of the safety functions envisaged in rule 6 and the safety officers shall work under him.

The Chief Safety Officer or the. Safety Officer where only one safety officer is required shall be given the status of a Senior Executive and shall work directly under the control of the Chief Executive of the factory. All other safety officers shall be given the appropriate status to enable them to discharge their actions functions effectively. The Safety Officer shall be provided with adequate technical and secretariat staff and such equipments as is required by them to enable him to function effectively.

By the above mentioned amendment of 30-11-2005 sub rules (c), (d) and (e) are added requiring pay scale, allowances and other conditions of the Safety Officers same as those of other officers of equivalent status. Dismissal of Safety Officer is not possible without the consent of the Director, Industrial Safety laid Health. Thus his service is now protected.

Duties of a Safety Officer:

Rule 6 and 7 regarding duties or functions of Safety Officers are reproduced below:

Rule 6: Duties of Safety Officers: The duties of & safety officer shall be to advise and assist the factory management in the fulfilment of its obligations, statutory, or otherwise concerning prevention of personal injuries and maintaining a safe working environment. These duties shall include the following namely:

1. to advise the concerned departments in planning and organising measures necessary for the effective control of personal injuries;
2. to advise on safety aspects in all job studies, and to carry out detailed job safely studies of selected jobs;
3. to check and evaluate the effectiveness of the actions taken or proposed to be taken to prevent personal injuries;
4. to advise die purchasing of stores department in ensuring high quality and availability of personal protective equipment;
5. to advise on matters relating to carry out plant safety inspection;

6. to carry out plant safety inspection in order to observe the physical conditions of work and the work practices and procedures followed by workers and to render advice on measures to be adopted for removing the unsafe physical conditions and preventing unsafe actions by workers;
7. to render advice on matters related to reporting and investigation of industrial accidents and diseases;
8. to investigate selected accidents;
9. to investigate the dangerous occurrences reportable under rule 103 of the Gujarat Factories Rules, 1963 and in the cases of industrial diseases contracted by any of the workers employed in a factory reportable under rule 104 of the Gujarat Factories Rules, 1963;
10. to advise on the maintenance of such records, as are necessary relating to accidents, dangerous occurrences and industrial diseases;
11. to promote setting up of safety committees and act as an adviser and catalyst to such committee;
12. to organise an association with the concerned departments, campaigns, competitions, contests and other activities which will develop and maintain in the interest of the workers in establishing and maintaining safe conditions of work and procedure;
13. Design and conduct either independently or in collaboration with the training departments, suitable training and educational programme for the prevention of personal injuries.

Rule 7: No Safety Officer shall be required or permitted to do any work which is inconsistent with or to the detrimental performance of the duties prescribed in rule 6.

This means that 'duties other than safety' should not be given to Safety Officers.

Now let us see general duties (vital role) of the Safety Officer as under:

1. He shall carry out all statutory duties, as mentioned above. He should constantly check the strict compliance of all statutory safety provisions.

2. Where no statutory provisions are available, he should find out necessary safety rules from Indian Standards, Codes, literature, technology, experience and should try to implement them.

3. He should analyse all accidents, their causes and remedial measures and keep the abstract of it

4. He should suggest and implement the requisite safety measures, after appraisal of factual and statistical data.

5. He should carry out job safety" analysis and plant safety inspection, for the purpose of safety.

6. He should behave as a friend, philosopher and guide to workers and the general public. He should fit the unfit to survive.

7. He should always study various books, reported and publications on safety and should find out things necessary for him. (A list is given in Reference No.6 at the end of this Chapter). Constant increase in knowledge of safety is necessary for him.

8. He should design and implement newer and safer working conditions and working actions. Safer working conditions include all safety devices, engineering controls and process revisions, machine guarding and preventive measures. Safe working actions of all workers will be possible after deep observation, attention and training of them.

9. He should pay more attention on "duty" rather than on "right". This position is like a driver of a vehicle and his primary duty is to save life and property both. He has to work for total loss prevention.

10. He should train all his subordinates and workers for their safety duties. A programme of constant training and refresher course should be arranged. He should be a good lecturer on safety. He should utilise modern techniques for safety training, should display more safety posters, signs etc, should observe Safety Day (4th March, Dashera,Vishwakarma Day) etc.

11. He should consult factory inspector, other Govt. authorities on safety, his co-officers, other safety people and workers in case of need.

12. He should use better check-lists (of safety points) for his factory.

13. He should devise and rehearse a safety manual and Emergency and Disaster Plan for his factory to control abnormal situations.

14. He should carry out preventive and corrective maintenance with the help of maintenance staff. He should advise and follow periodical checking and testing schedules for this purpose. All safety and health test reports must be filled in only after due checking and testing. He should thoroughly study Form No.8, 9, 10, II, 2.0, 21, 2.6A, 37 etc. of GFR and also other statutory safety records and try to minimise the accident rates.

15. For chemical hazards, occupational health and hygiene, diseases and poisoning, much attention must be paid by him. He must take utmost care for Chemical Safety. He should well study and implement all aspects of this chemical safety to prevent health injuries due to chemicals, their storage and processes, vessels, equipment, exposures etc. He must consider all factors affecting health and safety viz. work, working methods, working conditions, working environment including ventilation, temperature, contamination etc., maladjustment to work, physical and mental strain from heavy and monotonous work, high speed, long working hours etc. These factors require proper study, engineering controls, preventive measures, health check-ups, workers education and training.

16. As an adviser to the management, he should give his advise based on his knowledge, experience and judgement regarding safety decisions. .

17. As a consultant to the line organisation he should give assistance in suggesting safety measures, interpretations of rules, codes, standards and regulations on safety.

18. As a coordinator and leader of the plant safety organisation, he has to provide enthusiasm and guidance to keep the organisation active and productive. He has to generate team-spirit, evaluate situations and solve the safety problems. He should work in close harmony and collaboration with line management and trade unions to ensure that no aspect of safety is neglected.

19. He must ensure that basic safety rules are followed in the design stage of building, plant, process, storage, handling etc. and in all working conditions, actions, usage of machinery, materials and protective equipment, accident investigation, inspections and audit, preparation of emergency instructions, training courses, records, safety incentive schemes etc.

20. His role is of manifold personalities. In addition to technical knowledge, he needs attitudes and qualifications of a good leader to make succeed all safety programmes.

8.2.3 Work Suggestions for Safety Officer :

1. Creation of independent office, staff, furniture, stationary, records etc.. for exclusive work of safety planning, design and administration.

2. Creation of class-room with black-board, teaching aid, safety postures, slogans, literature and effective display to carry out training for workers, supervisors, executives etc.

3. Creation of necessary registers, records, checklists, inspection-proforma, accident investigation proforma, maintenance-proforma, test-records etc. for the purpose of safety of plant, machinery, material, equipment, building etc.

4. Display of safety posters, slogans, maxims, banners, stickers near main gate, canteen, restroom, pay-office, other work-rooms and places where workers can easily see them. As far as possible, they should be in the worker's language.

5. Display of summary of monthly accidents just at the main-gate and some prominent places to bring them to the notice of all concerned. Monthly accidents should be classified as fatal, non-fatal, due to machinery and working conditions, due to worker's unsafe actions and place/shed/plant of serious accidents in the factory etc.

6. Preparation, rehearsal and updating of on-site and off-site emergency plan of the factory.

7. Conducting regular classes for one or two hours for all workers, supervisors, executives etc. by rotation and in small batches. Explain them the hazards, safety precautions and safety duty pertaining to the factory. Use effective teaching aide viz. video, safety films, pictures, computer etc.

8. Carry out regular rounds for plant safety inspection and risk analysis of all plants/ sheds/stores/places to check .safe and better working conditions in the factory.

9. To study unsafe actions of the workers causing more accidents and try to train them for removal of such actions.

10. To get the speedy compliance of the remarks of the factory inspectors, certifying surgeons and other safety authorities and to send the reply thereof.

11. To procure necessary safety equipment including personal protective and fire fighting equipment and to give training to the workers for their effective use.

12. To check all accidents, investigate them and to take necessary steps to minimise-them. To keep a proper record thereof.

13. To check compliance of the provisions of the Factories Act, Rules and other Safety Laws. To keep ready the prescribed forms under them.

14. To prepare monthly, half-yearly and yearly reports of safety work done and to submit them to the top executive of the factory and other authorities when asked for.

15. To carry out the duties prescribed under the Gujarat Safety Officers Rules 1983, and mentioned in foregoing Part 8.2.2 of this Chapter.

8.2.4 Attitudes of the Safety Officer :

To elaborate the role mentioned in foregoing para-20of Part 8.2.2, some philosophical and psychological attitudes and qualifications (qualities) necessary for a Safety Officer are given below:

1. Always search for knowledge. This is the basic tool. In our country the importance of knowledge is well recognised since ages :

fo}Roa p u`iRoap] uSo rqY;s dnkpu A
Lons’ks iwT;rs jktk] fo}ku loZ= iwT;rs AA

This states that the knowledgeable man is greater than a king because king is respected in his kingdom while the knowledgeable man is respected everywhere.

;L;ukfLr Lo;a izKk] 'kkL=a rL; djksfr fde~ A
ykspukH;ke~ foghuL;] niZ.k% fda dfj";fr AA

He who has no knowledge is not benefited by books, for, a mirror is of no use to him who has no eyes.

O;lukfu lfUr cgq’k%] O;lu};eso dsoya O;lue~ A
Fo/;kH;lua O;lua ;n~ ok gfjikn~lsou O;lue~ AA

Habits are many but only two are important a habit of learning or a habit of serving the feet of the God.

Now, how to acquire this knowledge? This is well explained by Gita as:

Rf}f} izf.kikrsu] ifjiz’usu lso;k A
Mins{;fUr rs Kkua] KkfuuLrRonf’kZu % AA

Know it by leaning down, interrogating and serving the Gums (men of knowledge) who will induct that knowledge into you.

2. Help of teacher/preacher is useful to interpret the knowledge.

xq: xksfoan nksuska [kM+s] fdldks ykxw ik; A
cfygkjh xq: vkidh] xksfoan fn;ks crk; AA

A teacher is greater than the God, because, it is the teacher who showed the God.

3. After acquiring the knowledge, work with full concentration. Example of Eklavya is eye-opening. Do everything carefully, nicely and whole-heartedly.

4. Make full use of the library. Read maximum books and reports on safety. Gain the working experience based on that knowledge.

5. Have tremendous self-confidence and work hard till the goal is reached. This is the only way to any success. What is the distance between success and failure ? "It is only three feet" was replied by a young American Engineer who drilled three feet more and received the goldmine. This distance is "only one stroke" as it was proved by Maharana Pratap in the famous fight of Haldighati. This distance is "only five minutes as the success was seen by Captain Nelson by waiting for five minutes only. The secret of success explained by Marshall Fox is that "simply determine not to be defeated". The cutting of ropes by Suryaji just before the capture of Sinhgadh proved the same thing. William the Conqueror said it "to burn your bridges". The escape of Shivaji from Agra fort became possible only due to his unparallel tremendous self-confidence.

6. After gaining knowledge and self-confidence as above, proceed to implement the knowledge of safety.

7. Insist more on engineering controls. Personal protective equipment should be the last resort.

Such attitudes are most useful to nil safety personnel for success in their work and life.

9 SAFETY PROGRAMME

9.1 Formulating the Programme:

Safety programme means a method employed by management to share and to assign responsibility for accident prevention and to ensure performance under that responsibility.

Four basic Elements (essential prerequisites) of Effective Safety Programme are:

1. Forceful continuous executive leadership.
2. Plant and equipment must be free from hazards.
3. Supervision must be competent and intensely safety minded and
4. Full co-operation ,in preventing accidents or health effects from all levels.

Of these the second element is more important as it is the main object of any safety programme.

9.2 Introducing and Developing the Programme :

Two purposes of any safety programme are to reduce hazard factor and to develop safe behaviour of all employees.

For the first purpose of reducing hazards the required activities are: (1) Planning for safe and clean technology (2) Safety in purchasing (3) Inspection (4) Job Safety (or hazard) Analysis and (5) Hazard investigation and (6) Prevention by remedial measures.

For the second purpose of developing safe behaviour the required activities are: (1) Placement (2) Training (3) Supervision (4) Education -and (5) Employee participation.

The techniques to detect unsafe behaviour are not so definite and clear-cut as those to detect unsafe conditions, because the human behaviour is not fixed like machines or materials. It is live and changing from time to time arid responding in different way due to different reaction. Chapter-3 explains this psychology of human behaviour. Therefore a programme of developing and maintaining safe "behaviour includes selected placement for a selected worker, education, training and supervision allowing participants in safety committee, advertising and publicity of safety rules and motivational slogans. Perhaps on-the job safety training by personal contact is more effective. Unsafe actions should be corrected till full rectification.

9.3 Evaluating and Reviewing the Programme :

For full success of any safety programme it should be evaluated and reviewed from time to time. Chauler-19 suggests such appraisal methods. The appraisal keeps the performance up to the mark. Careful watch for safe performance is necessary. The top executive can set suitable goals and means of gauging improvements in human behaviours.

The benefits of value measurement of safety activity/programme are: (1) It conveys to the top management the status of safety efforts and safety development (2) It enables the safety professional to promote effective loss prevention measures (3) By comparing weighted score from year to year, the progress is monitored.

Methodology: Various criteria are selected for evaluation. Weighted values are provided to each sub-activity under each criterion. This way it can be known in advance what is going to be measured and how the results will be compared with the previous results. The evaluator should have good grasp of the operations and the expected standard of the activity.

Main Criteria or area for evaluation are : (1) Organisation and administration (2) Industrial hazards control (3) Fire control (4) Industrial hygiene and health (5) Supervisory participation, motivation and training and (6) Accident investigation, statistics and reporting procedure. Each of these criteria are subdivided into 4 to 6 sub-criteria and rating (marking) is given to each of them as poor, fair, good and excellent. One model rating form used by Dow Chemical Co. (USA) is given in Table-5, Chapter-32.

10 SAFETY EDUCATION AND TRAINING

10.1 Definitions :

R. P. Blake has explained the difference of education and training. He says, "Education deals with developing the mind, broadening knowledge and understanding. Education in a specific subject means acquisition of broad and thorough knowledge m .that subject. Training deals with the development of skill in performance. In industry it refers to the skilled trades as applied to safety. Education and training are not completely separable, each participates to some extent of the nature of th» other. Safety Education is for developing safety mindedness - a vivid awareness of the importance and correcting conditions and practices that might lead to injury. Safety training is for developing the worker's skill in the use of safe work techniques and practices. It is described as a detailed extension of the educational safety programme applied to specific occupation, processes, jobs or activities".

Oatey (1970) defined training as "Any activity which deliberately attempts to improve a person's skill at task".

Hesseling (1971) defined it as a sequence of experiences or opportunities designed to modify behaviour in order to attain a stated objective.

Hamblin (1974) defined it as "Any activity which deliberately attempts to unprove a person's skill on a job as opposed to education which is mainly concerned with personal development and not related directly to the job."

McCormic & llegen (1987) opined that the crux of training is that "It is the management of learning. It is an organised procedure which brings about a semi-permanent change in behaviour for a definite purpose. When this definite purpose is "Safety", it defines "Safety Training".

A functional definition of training is the acquisition of concepts, theories, knowledge, skills and attitudes so that employees are equipped to perform competently in their present or future jobs resulting in increase of efficiency of the organisation as well as their own job satisfaction.

On the other hand "development" is defined as lie application of acquired knowledge, theories, skills and attitudes to the job for increasing organisational effectiveness.

Training is one way to develop a more flexible rand efficient work force. Modern technological change is a driving force behind today's training, especially in technical areas. Modern technology also brings hazards and suggests remedial measures. Therefore safety training is becoming more and more essential to develop a skilled and motivated work force to understand and identify hazards, to find out and apply the appropriate safety measures to maintain safe working conditions-and actions.

Safety Training is an extension of educational safety programme applied to specific activities or process viz. industrial activities, work on machines, .chemicals etc.

10.2 Elements of Training Cycle :

As per OSHA (Occupational Safety & Health Act)'s training guidelines, seven chronological steps are suggested to complete a training cycle. These are the basic elements of any safety training programme. Fig. 6.14 shows them in a cyclic order.

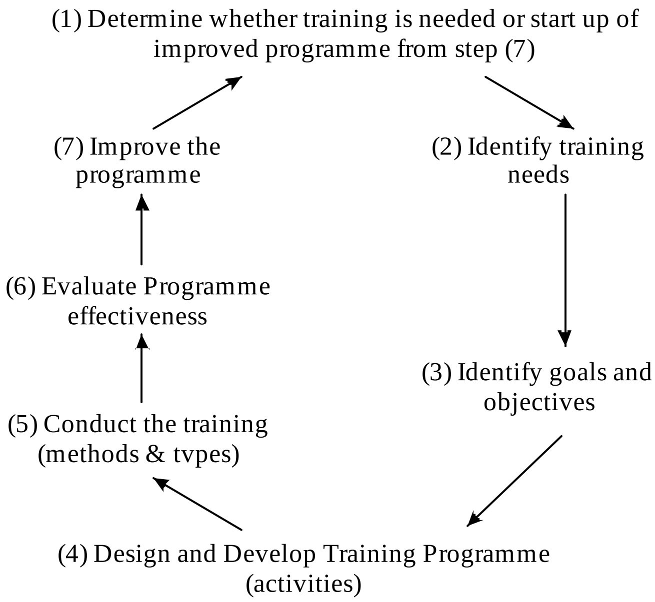

Fig 6.14 Training cycle

These steps are explained as under:

1. **Determine if training is needed** - The first step is to determine whether a problem can be solved by training. All skill deficiencies are not solvable through training and some other tool may be required. This step includes need of any improved (revised) training programme.

2. **Identify training needs** - Analyse the worker's duties and what he or she needs to perform the job more skilfully and safely.

3. **Identify goals and objectives** -A list of specific job knowledge and skill deficiency derived from Step-2, will fell employers what workers should do, do better or stop doing.

4. **Design & Develop training programme** - After listing precise objectives and goals, learning (training) activities must be identified and described. Type of training will be decided based on the training resources available to the employer, the kind of knowledge or skills to be learned and whether the learning should be oriented towards physical skill or mental attitudes.

5. **Conduct the training** - Now the training programme should be conducted by (a) providing overviews of the material to be learned and (b) relating each specific item of knowledge or skill to the worker's goals, interests or experience to be learned.

6. **Evaluate programme effectiveness** - By knowing trainee's opinion, supervisor's observation, work place improvement, hazard reduction, performance improvement etc., it should be checked whether the training has accomplished its goals.

7. **Improve the programme** - Based on feedback from the workers, supervisors etc., and from evaluation and observing the gap, the training programme should be improved (revised) as per need.

10.3 Assessment of Training Needs :

The first step of any training process (cycle) is to be sure about the needs. Following four questions (approaches) should be considered:

1. Does an actual or potential performance discrepancy exist ? (viz. unsafe conditions, actions, efficiency).
2. Is it important to the organisation ? (viz. in reduction of cost of accident, hazards, losses etc.).
3. Is it important to the employees ? (viz. basic training to new employees, refresher course for old employees, more mistakes by workers, more accidents to them).
4. Is it correctable through training? (If yes, then only the training becomes useful and cost effective.

General training needs are assessed from following grounds:

1. New employees are not very clear about job description. Therefore training is essentially required for them.
2. Old employees require knowledge of new topics, new technology, process revision, new methods and forgotten old items. Training for emergency preparedness, safety audit, fire fighting, hazard detection etc. are also necessary for them.
3. Change of position due to promotion or transfer. New position may require training.
4. Technological changes in the organisation. Addition of new material, machine, method, process, equipment etc. create need of training.
5. To make a person more versatile to do more than one job (safety supervision, accident analysis and computer data feeding).
6. When performance, productivity and efficiency fall down at any level, training may improve them.
7. Supervisors/foremen feel need of training for workers working under them.
8. Records of production, turnover, accidents, absenteeism, rejects, errors, wastes point out areas of training.

The safety training programme is generally needed for all the times as an induction or introductory course or a refresher or ongoing course but is specifically needed when

1. New employees are recruited
2. New plant, material, process or equipment are introduced
3. When safety procedures are evolved or updated
4. New information of hazard is received
5. Safety performance needs to be improved
6. The accident rates are increased
7. Labour turnover is increased and
8. Excessive waste, rejects and scrap are noticed.

Under sections 7A (2) (c) and III A (ii) of the Factories Act new provisions are added for training to ensure the health and safety of all workers at work. This is statutorily required as under.

Every worker shall have the right to get trained within the factory or at a training centre or institute duly approved by the Chief Inspector, where training is imparted for worker's health and safety at work.

Four-approaches are suggested to determine safety training needs as under:

No.	Approach	Content
1.	Common concepts approach.	Assess own situation / requirement based on real need. Specific result oriented programme instead of general knowledge.
2.	Safety need analysis approach.	Job Safety Risk Analysis useful. Gap between job requirement knowledge and employee knowledge suggests training need.
3.	Problem Identification approach.	From employee's performance appraisal report, his need can be assessed and fulfilled by personal coaching, instructing, guiding etc.
4.	Organisational Safety Survey approach.	Classify and analyse accident and calculate and compare performance rates. Conduct hazard survey. Study existing safety measures, interview key personnel and arrive at needs and deciding priorities.

10.4 Objectives of Training:

Training cannot and should not be started without any pre-decided objective. Training without objective (purpose) or for the sake of training is of no use and becomes wasteful activity. Training need must be assessed first and from that the objective(s) should be specified as under :

1. Transmitting information about policy, product, services, accident causes and remedial measures, new process, methods and technology or the company itself.
2. Developing skill for safe behaviour and to work efficiently.
3. Modifying attitudes more favourable to safety, production, co-operation, discipline etc.
4. To give a worker a new, necessary and broader view point of his safety responsibility
5. To explain him potential hazards of unsafe working conditions, actions, environment and safe views to prevent them and
6. To increase his safety consciousness, perception of danger, knowledge, experience, confidence, responsibility and ability in safe performance.

10.5 Techniques (Procedure) of Training: Competence Building Technique (CBT)

The concept or basic object of any training is to generate or build competence in participants (workers). Only knowledge is not sufficient. Knowledge alone cannot give competence or confidence of safe or successful working. Knowledge should be put into practice by necessary training. Training shows the practical part of knowledge and generates competence of work gradually.

Competence in safe working is necessary. Due to advancement in technology, new processes, new equipment, modification or changes, training is always required to become familiar with tins. Therefore, safety is an online function. It should not end with any slogan, suggestion, award or safety day celebration.

It should be considered as' a part of continuous or ongoing activities. For this purpose, induction training and refresher training are organized. Effective communication system should be utilized. Role of multimedia and computers should be utilized. Safety films, pictures, hazard points, accident case studies etc should be shown and explained during training.

See Part 10.8 to 10.14 for different roles, teaching aids, and techniques of success training.

A good safety training programme contains following steps:

1. Determine safety training needs and priorities by four approaches stated in Part 10.3
2. Design training to meet the needs. The steps are: (a) Assess training requirements (b) Determine training contents (c) Decide training methods and aids (d) Organise training content (e) Formulate training plan and (f) Decide evaluations measures.
3. Implement training process. The steps are: (a) Discuss with company officials (b) Decide administrative aspects and time schedule of training (c) Execute (give) training to the decided trainees (d) Monitor the programme (e) Conduct review of safety training and (f) Have follow up of trainees.

Techniques of training are generally the "training methods" which are discussed in detail in Part-10.7 following. All these training (teaching) methods are broadly classified into two types of techniques known as off-the-job techniques and on-the-job techniques:

(A) Off-the-job training techniques :

No.	Category	Techniques (methods)
1.	Information presentation techniques (less involvement of trainee).	Reading list, Correspondence course, Films, Lecture, Panel discussion, Programmed or Computer based instruction.
2.	Information processing techniques (trainees are involved).	Conference or discussion group, T (training) group.
3.	Simulation techniques (experiment or practice).	Incident / case, role playing, In-basket, Vestibule, Mock-up, Business game.

(B) On-the job training techniques :

No.	Category	Techniques (methods)
1.	Actual job assignment.	Coaching, Job instruction training (JIT).
2.	Temporary job assignment.	Special assignment on job, committee, project etc. job rotation through predetermined set of jobs to provide exposure to different part of the organisation.

10.6 Design and Development of Training Programme :

Any training programme should be designed for its specific purpose. Design and development of safety training programme need systematic job safety or risk analysis. For steps (detail) of such analysis see Part 1.5 and 4.3 of Chapter-19.

Following general points are useful in designing and developing any training programme.

1. Motivation should be the first condition of any type of training.
2. Number of lessons and content to teach should be well designed beforehand. Steps or sequence of topics should be decided.

3. The amount to be taught in an unit (period) should not be too large or too small.
4. An objective of the training should be decided and the training process should move toward it. The training procedure should be developed.' A list of training aids should be prepared.
5. The task to be performed should not be descril)ed only but it should be demonstrated in actual or simulated conditions. "Doing" is important than mere "Hearing" or "Seeing". Practice makes perfect.
6. The demonstration (by teacher) should be followed by the learner (trainee) as soon as possible before' he forgets it. The teacher should be given feedback or knowledge of results.
7. Questions of learners should be properly replied and discussed at all stages (steps).
8. Ample practice opportunity should be provided and practice encouraged.
9. Frequent and accurate knowledge with examples, pictures, practical etc., speeds up learning rate and motivation.

10. The training should be taken to the point of goal and not be left unfinished.
11. Effectiveness of the training should be evaluated and conclusion be drawn to revise (improve) the training programme and it should be followed in the next cycle.

According to Gagne, any human task (including safety) can be analysed into a set of component tasks (Job Safety Analysis, Part 1.5, Chapter-19). The basic design of any training should consist:

1. Identifying the component tasks of a final performance.
2. Ensuring (in training) that each of these tasks is fully achieved or mastered by the learner.
3. Arranging the training of the task components in such a way that there will be positive transfer from learning of one to another.

The design work may be done by specially designated training professionals, especially for programs to be offered several times or left to individual instructors.

Main design steps include (1) Setting instructional objectives (2) Determining programme content.. and (3) Selecting instructional techniques for off-the-job and on-the-job training.

10.7 Training Methods and Strategies :

Aspects and Goals : The training methods have two aspects:

1. Theoretical or formal in the classroom and
2. Practical or informal in the job place.

There are two basic goals :

1. To explain the worker to know the job and to do it correctly and
2. To be certain that he knows how to do it ' correctly.

Steps: Any training method should have following steps:

1. Lay down the objective of the training programme.
2. Prepare the training programme.
3. Brief the trainee.
4. Use audio visual aids where appropriate.
5. Review the contents and
6. Follow lip with trainees when the programme is completed.

Effects of Methods : Effectiveness of different training methods is given by Bird as follows:

A trainee tends to remember 1-0% of what he reads, 20% of what he hears, 3Q% of what he sees, 50% of what he sees and hears, 70% of what he sees as he talks and 90% of what he says as he does a thing. This percentage is variable depending upon one's memory power, intelligence, grasping, understanding, susceptibility and interest in the subject. It also depends upon the explanation power. These factors can be developed by education and training. Speaking, writing, involving and doing are the most effective exercises to digest any subject.

Types of Methods : Some usual methods are: Lecture method, discussion method, case study, role play, project work, programmed instruction, on-the-job instruction, training aids, fault analysis, algorithm as an aid to fault analysis, fault tree analysis, drill, demonstration, panel or group discussion, meeting, simulation, pictures and posters, films and closed circuit television, filmstrips and slides, projectors and microphones, charts, boards, and working models, checklists, exercise, rehearsal and use of press and other mass media.

Thus methods are many from old to the ultramodern. Which method is the best? No one method can be named. Appropriate method should be selected depending upon the size, age and experience of the group, the amount of material, type of presentation necessary and time and money available. Selection of method requires skill and experience. Result of effectiveness depends upon it. Therefore make the best choice of the method and apply it successfully. Display of relevant safety posters at workplaces contribute much without saying.

Some common methods in use are mentioned below:

1. **Lecture Method :** Oldest and most basic method. Well planned lectures can cover a large amount of information in a short time. More useful when participants are more, or their involvement is less required.

2. **Discussion Method :** Useful with small number of people in a group. The trainer acts in a limited way as a scene setter or referee encouraging participants to speak out. The two way communication moves toward objectives. Participants are more attentive, active and don't feel boredom.

3. **Case-study Method :** Accident case study is presented explaining how an actual accident happened or an imaginary accident can happen. Causation analysis and remedial measures can be discussed by questions and answers. Good pictures are more useful to explain the situation effectively. See Chapter-30 for accident case study.

4. **Role playing method :** It is a form of learning by doing but in a simulated situation. Trainees are given 'a situation like in case-study method but instead of just discussing it they resolve the problem by acting out the roles of the people involved. Here extrovert trainees show their skill but introvert or shy trainees unused to such situation get embarrassed.

5. **Business Games Method:** More useful for business people and skill required for safety attitude or inspection in buying/selling items which are more safe or with the details of safety.

6. **Sending at training Centres :** Institutes, seminars, workshops, special courses etc. utilises external resources for required training.

7. **Job instruction training:** Useful to train supervisors who in turn train the employees. Job instruction training (JTT) involves four steps (1) Preparing the trainee (2) Demonstrating the job (3) Having the trainee performed the job and (4) Checking frequently the trainee's performance. All new job assignments should be preceded by on-the-job training. Each step of job safety analysis (JSA) is explained with hazard, safe procedure and use of safety equipment. Use of guards and controls are also explained.

8. **Programmed instructions :** Programmed instructions are given in a book form. A trainee learns it, answers the question or solves the problem. The system has mechanism of learning-checking and relearning.

9. **Project work :** Project writing is given to trainees. They apply their knowledge to practical situations.

10. **Other methods :** Job rotation, committed assignments, HRD training, sensitivity training, creativity training, in-basket training etc. are other specific methods.

10.8 Types of Safety Training :

Types of safety training are formal and informal. Formal training may be general or specific.

General Training includes -

1. Induction courses for new employees.
2. On-going safety training.
3. Safety representative training.
4. Supervisory training.
5. Senior/ middle management training and
6. Directors training.

Specific Training includes -

1. Safety system of work for particular operations where the potential hazard is high and guarding is not feasible.
2. First aid training.
3. Specific items of plant or equipment.
4. Use of protective equipment.
5. Fire precautions.
6. Safety inspections.
7. Change of job for which a worker is not trained.
8. Role of workers in emergency planning.
9. Techniques of safety audit, Hazop, Hazan, FTA, ETA etc.
10. Safety permit system.

Some details are given below:

1. **Orientation or Induction Training :** It is obvious that new employees may not be knowing much about the factory they joined, its safety policy, specific raw-materials, their characteristics, processes, methods, pollution control, health check-ups, role in emergency planning, first-aid, fire fighting, use of personal protective equipment, accident record, hazards of their work, remedial measures and workplace monitoring etc. Therefore it is always useful to design training on such subjects for the new employees. This basic knowledge builds their confidence, skill and interest towards the work and the company both. See also following Part 10.9 - for "Training to New Workers".

2. **Apprenticeship Training :** A learner who has just completed his school or college education or is still undergoing it and agrees to work as a trainee or apprentice or employed under the Apprenticeship Act as an statutory requirement, is given this type of training. It is a combination of on the job and off-the-job training taking the strengths of both. Intention is to show him the practical or applied part fitting to his type of education.

3. **On-the-job training** is practical in nature and generally takes place on the job. Such job contact sessions may involve individual on one to one basis with the supervisor training an operator for the work he has to carry out.

First the supervisors are trained for this purpose showing them the job safety or risk analysis. Then in turn they train the employees mostly new. It imparts necessary skill for the job involving worker to do the job systematically and safely. Injury to the trainee or the job is possible due to normal mistake of the trainee. Therefore its usage is limited to situations where mistakes can be tolerated. Airline pilots and Surgeons are allowed on the job practice only after their skills have been sharply honed using off the job simulation techniques.

Some methods used in this type of training are coaching (personal attention), job instruction training (JIT), special assignment and job rotation.

It is supervisor's or training instructor's responsibility to train the employees under him for safe methods, machine guarding, identification of hazards in each step and its remedial measure, need and use of safety equipment, avoidance of shortcuts, hasty actions, overconfidence etc.

4. **Off-the-job training :** All types except on-the-job are called off-the-job training. It includes classroom or lecture method, audio-visual, film, reading list, books, correspondence course, panel discussion, conference or discussion group, T-(training) group, computer based instruction, case study, role playing, in-basket, vestibule, mock-up, business game etc. and explained as "training methods" earlier.

5. **Vestibule Training:** It is an approach between on-the-job and off-the-job training and used when the job is dangerous and can harm the trainee if taught on the job. The training takes place away from the actual work place but the equipment and procedure to be followed are similar to be used on-the-job.

6. **Individual and Team Simulations:** Equipment and procedures that duplicate actual equipment and work conditions as closely as possible are known as "simulators" e.g. set up for training pilots and astronauts. When economic or human costs of error are very high, this type of training is safe and cost effective.

7. **Team Training:** It is required to increase coordination and co-operation amongst team members and make them realise that their behaviour may help or hinder co-workers from performing effectively.

8. **Individualised or Programmed Instructions:** This is a technique to supply instruction through printed material or machines. Safety instructions by placard, slides, banners, notices, boards, film, transparencies, check list etc. are useful. It eliminates need for an instructor and trainees can learn when and where they choose. They do not have to be assembled at one place and one time. This type is useful where a number of trainees cannot be spared from their duties simultaneously.

9. **Modern methods of Training:** It is a derivative of programmed instruction and utilises computer as medium of instructions. A computer is fed with the entire programme of presenting material asking questions and evaluating responses.

The computer adjusts instructions according to the learner's abilities, prior'knowledge and his replies to computer's questions.

It is like a private tuition by a computer as teacher who has full command of the subject and who never gets tired of repeating replies. It gives immediate feedback without sarcasm, anger or error. The disadvantage is the cost of computers and programs if they are need in bulk to supply individually.

See Part 10.13 for training aids.

10. **Other types:** Types are also classified as technical training, HRD training, safety training, productivity or creativity training, voice training, ISO training, computer training, customer training, supervisor's training, training for training etc.

Now-a-days importance of training is widely accepted at all levels. Type should be selected best fitting to our need and budget.

10.9 Training of Workers and Supervisors :

Safety training should begin with every new worker and continue till he is in the service. Successive steps may be increased. Japanese system of weekly training (one day .in each week for training) is the best example of such training. The type of training, frequency, content and trainer may vary according to the need and type of industry.

Training to New Workers :

Safety training should be given to all new workers, irrespective of previous experience. He should be taught:

1. Safety Policy, rules and practices of the company. Provisions for safety committee.
2. Worker's duties and rights under the Factories Act and other safety statutes.
3. Emergency signals and their meanings.
4. Observance of warning signs and symbols.
5. Location of means of access, phones, fire alarm and extinguishers, emergency exits and procedure, first-aid and ambulance room, safety office, assembly points etc.
6. Types of protective equipment, their need and practice to wear them.
7. Types of hazards of his job and safeguards provided and to be maintained.
8. Safe practice and full job instruction for his job.
9. Codes and standards to be followed.
10. Records to be filled in.
11. Means of reporting hazards, absence of guard or defective equipment.
12. Need for good housekeeping.
13. Types of frequent accidents in his plant and means to avoid them.
14. Not performing any new job or machine without first learning from the supervisor.
15. Seeking medical assistance in case of any type of injury and reporting it to the supervisor.

Even older and experienced workers need periodical job safety training and new knowledge to them. Safety meetings and .various types of safety refresher courses should be arranged to increase their job-training and safety performance.

Training to Supervisors:

Training to supervisors is most important because safety and production control are associated with supervisory functions and it is their main duty to prevent accidents. Objectives of safety training to supervisors include

1. To explain them their principal responsibilities of establishing work methods, giving job instruction, assigning people to job, supervising people at work and maintaining good housekeeping, plant and equipment.
2. To acquaint them with the company's safety policy, rules and practices.
3. To emphasise that accident investigation work is solely for prevention purpose and not for fixing blame.
4. To establish their status of a key-man for safety and production.
5. Ways and means to maintain safe conditions and actions.
6. Special information on accident causes and methods of prevention, particularly in their areas "of work. Case studies of actual accidents.
7. Job instructions for safely, supervising for safety, accident reporting, investigation and. record writing, job safety and risk analysis and group meetings for safety etc.
8. Ways and means of job training to workers and training aids.
9. How to participate in planning of safety programme and safety committee.
10. Solving of supervisory problems. The steps are :
    (a) Identify the problems.
    (b) Find and verify the reason for the existence of the problem.
    (c) Select the appropriate remedy and apply the remedy.

Some supervisory problems are stated below :

Kinds of Supervisory Problems :

1. *Work Problems*: (1) Error of commission or omission (2) Insufficient work (3) Poor work quality (4) Breakage, wastage, spoilage etc. (5) Improper methods, tools, equipment etc.
2. *Procedure, Rules etc.:* (1) Violation of rules (2) Failure to report facts (3) Abuse of privileges (4) Failure to maintain premises, tools etc. (5) Play, gossip, loafing etc.
3. *Additional Problems:* (1) Direct refusal or insubordination (2) Assumption of unwanted authority (3) Loose talk (4) Ridicule of criticism of the company (5) Creating disturbance, noise etc.
4. *Personal Problems:* (1) Dissatisfaction, wages, treatment, unhappiness (2) Chronic tardiness -or absence (3) Outside, home, social situations (4) Demands for premature promotion (5) Trivial tale bearing.

Reasons and Remedies of Supervisory Problems :

Reasons for existence of problems: (1) Lack of skill (2) Insufficiently informed, misunderstands (3) Not convinced-indecision (4) Finds standard procedure difficult, awkward etc. (5) Spare, light, tools etc. inadequate, unsafe etc. (6) Physically unsuited (7) Personal characteristics unsuited.

Remedies: (1) Engineering or process revision (2) Persuasion and appeal (3) Personnel adjustment (Placing and medical treatment (4) Psychological treatment and (5) Discipline.

10.10 Individual v/s Mass Training :

Both are necessary. When common things are to be taught, mass training saves the time and therefore it is mostly utilised. Class-room or workshop training, lectures and demonstration, seminars, tours, radio, TV and all audio-visual methods are invented for effective mass trailing. Individual training is on-the-job training and it is mostly given by a supervisor to a new worker or wherever necessary at the work places. Handling tool or material, setting and performing job, art of repairing, wearing, and using personal protective equipment, using fire extinguishers, gas-detectors and other safety -devices, calibrating, testing and examination, driving, report writing etc. need individual training for good practice.

Disadvantages of mass training are: (1) Individual attention is not possible and it is not equally utilised by all (2) It is hasty (3) Things which are to be seen at the situation cannot be explained properly (4) Use of mass training aids requires expenditure.

Disadvantages of individual training are (1) It requires much time, patience and skill (2) All are not trained at a time (3) Groups cannot be trained (4) Advantage of expert's teaching or seminar is not possible for an individual. Its main advantages are: it is cheap, builds personal relation and provides in depth training.-

10.11 Need for Re-training (refresher course):

This is also felt necessary to refresh the memory and maintains skill and ability for continuous good performance. Generally higher officers and top executives are more benefited by periodical re-training, because owing to their attention divided on multiple administrative and technical matters their chances of forgetting particular details are more.

When it is felt that a worker has started making mistakes or accidents, it indicates need of re-training. Before giving re-training facts of past training should be known for guidance.

10.12 Integration of Safety Training with Job Training :

This is necessary to increase overall knowledge of doing the job safely. With specific subjects if some safety subjects are integrated, it promotes safety in better ways. In a big concern the manager of training and the safety manager should work together in the planning of various kinds of training programmes. Generally safety training should be job oriented to bring perfection in job performance. If safety training is not so integrated, it is of little use. Therefore at the planning level such integration should be designed to extend the maximum benefit of safety training. Safety should be part and parcel of the job or industrial activity and such integration should be -like a chemical compound which is deferred from mixture.

Curriculum for degree, diploma and craftsman courses in engineering must contain more and more safety subjects at teaching and training levels.

10.13 Types of Training Aids :

Following aids are useful in training :

1. Black boards, magnetic boards and flannel boards.
2. Charts, drawings and posters.
3. Slides, filmstrips, transparencies and overhead projector.
4. Printed material like books, manuals, handouts etc.
5. TV and Movies.
6. Scale, models, mock-ups, training devices and simulators.
7. Computers, Software (e.g. power point, page maker, graphic design and display etc.), CDs, LCD projector etc.

Training or teaching aid should be selected judiciously to make learning interesting, meaningful and without boredom or monotony. Just after lunch interval in the afternoon, film may be more effective than mere lecture. Where machines and equipment are used as aid, they should be safe and clean and their safety and ergonomic aspect should also be explained.

10.14 Evaluation & Reviewing of Training Programme :

An evaluation i.e. measurement of effectiveness or result of the training programme conducted, is useful in reviewing .the programme content, method, aid and redesigning the programme as per feedback for improvement. An effective training programme should show;

1. Increase in quantity and quality of production.
2. Increase in production rate.
3. Increase in knowledge, skill and ability about job performance.
4. Increase in job satisfaction and motivation.
5. Decrease in accident rate.
6. Decrease in production time, breakage or use of consumable items.
7. Decrease in absenteeism.
8. Decrease in labour turnover.
9. Decrease in job turnover.
10. Decrease in operational cost.
11. Refinement of human behaviour towards intended objective or goal viz. safety outlook, interest and safety mindedness, production and quality orientation etc.

The benefits of value measurement of safety training programme are:

1. The top management understands usefulness and cost effectiveness (in relation to accident costs) of the training programme.
2. Confidence, morale, skill, status, prestige etc. of the employees and the company itself are seen improved.
3. Most effective loss prevention measures can be segregated for repetition.
4. Strengths and weakness are highlighted and suggest the steps for next programme.
5. Safety professional can find out and promote most effective programmes.
6. It can be determined whether objectives/goals are met and reason of gap if any. This is useful in reviewing the programme.

For evaluation participant and/or supervisors reaction should be assessed through interviews or questionnaires. Following questions are useful in such assessment.

1. How much change occurred ?
   The criteria include knowledge, attitudes, skills, behavioural change on the job and/or improvements or decrements in organisational results. These criteria can be measured by paper and pencil tests, questionnaires, work sample tests, timings of performance etc.
2. Can the change attributed to the training programme ?
3. Was the training worth the effort ? Here cost of training is justified against gain to the organisation.
4. Whether employee development needs are fulfilled ?

This can be judged through effectiveness, efficiency and affirmative action and helps to guide decisions concerning planning, programming and budgeting.

Assessment is carried out by using Rating Form (see Table-5, Chapter-32) where activity standards and rating norms (poor, fair, good, excellent) are prescribed and marks are given. Activity standards can be decided for (1) Organisation & Administration (2) Industrial hazard control (3) Fire control (4) Health and Hygiene (5) Participation, motivation and training (6) Accident investigation, statistics & reporting procedure etc.

After evaluation, its results should be utilised to review the programme. Such review will give (1) Agreed recommendations for future action (2) An agreed action plan for the department (3) A follow-up and action plan for agreed recommendation.

After review a new (improved) safety (training) programme will take shape with drawbacks filtered and more effectiveness and usefulness reinforced. This process of refinement of better and better training programme yields good results.

11. EMPLOYEE PARTICIPATION IN SAFETY

11.1 Purpose :

Employees are the major work force working under hazards. Some know the hazards and some do not It is of great importance that they must realise that they would be the first victim of any accident, their safety awareness and all accident prevention work is in their interest and therefore their active participation in showing hazards and helping in removing them by the joint efforts of management and all employees is most desirable.

Section 41G of the Factories Act speaks worker's participation in safety management. A method of safety committee is suggested. Right of workers to warn about imminent danger is also created by sections 41 H 111A of the Act. Display of the Extract of the Act and Rules (Section 108(1), Rule 106 and Form No. 23) is for the same purpose of making workers aware and to call for their participation. Some areas and methods of participation are discussed below:

11.2 Areas of Participation :

General areas of participation are as under :

1. To set safety goals and training programmes.
2. To design and improve standard operating procedures (SOPs) and methods of operation.
3. Appraisal of progress towards goals.
4. To give, collect and discuss safety suggestions and to implement which are necessary. Rewards for good suggestions boost up motivation for participation. '

McGregor's theory states that **participation management** has a basic belief in the competence and abilities of individual employees regardless their status in organisation. Employees' and supervisory participation is essential for success of any safety programme.

When workers are taken into confidence in designing any .safety programme or goal they feel themselves responsible for its success. This element of involvement and joint responsibility is most fundamental to employee participation.

Statutory areas are discussed in Part 11.3.1 below.

11.3 Methods of Participation :

11.3.1 Safety Committee :

Rensis Likert has described four types of management systems within an organisation (1) Exploitative authoritative (2) Benevolent authoritative) Consultative and (4) Participative. This last approach of participative concept is adopted by many countries and joint efforts of workers have resulted in reducing accidents.

Statutory Provisions:

A new provision was added since 23.09.87, u/s 41 G of the Factories Act to set up a safety committee consisting of equal number of representatives of workers and management to promote co-operation between the workers and the management in maintaining proper safety and health at work and to review periodically the measures taken in that behalf.

Thereafter by addition of rules 68F&Y in the Gujarat Factories Rules, on 15-2-1995, following revisions are added regarding safety committee :

Applicability:

1. Factories employing workers more than 250.
2. Factories carrying dangerous operations u/s 87.
3. Factories listed in the First Schedule.

Formation, Tenure & Rights:

1. A senior official shall be the Chairman.
2. A Safety Officer or Factory Medical Officer shall be the Secretary.
3. A representative each from the production, maintenance and purchase departments shall be members.
4. Workers representatives, of equal number, shall be elected by the workers.
5. The tenure of the committee shall be 2 years.
6. At least one meeting in 3 months. Minutes shall be recorded and produced before the Factory Inspector on demand.
7. The committee has right to be informed of potential hazards of work places and data on accidents and working environment. The committee shall keep the data confidential and use it solely to guide on safety measures.

Functions & duties:

1. Co-operation to implement health and safety policy.
2. All matters of health, safety and environment and solutions to problems in that regard.
3. Creation of safety awareness amongst workers.
4. To conduct educational, training and promotional activities.
5. To discuss reports on safety, health and environmental surveys, safety audits, risk assessment, emergency plans and implementation of the recommendations of the reports.
6. To carry out health and safety surveys and identify causes of accidents.
7. To look into complaints of imminent danger and suggest corrective measures.
8. To review the implementation of its own recommendations.
9. To form sub-committees, if necessary.

The main object of the committee is to advise to Managing Director and the Safety Board or the top executive of the company on all matters of safety and health of the workers. It is not a substitute for the management. Like other committees it is an organ or part of the management function and helps the management in specific area of safety. It is a body of safety representatives for group suggestions and decisions, co-operative safety efforts and a two-way channel of communication through which suggestions can flow from employees to management and vice versa. It does not bypass the overall management control of general supervision and communication, but it aids to it.

Its advantages are: It (1) brings together varying view points, yield sounder .decisions than the individual members (2) widens interest by allowing participants of work-people in their own .work and (3) allows checks and cross-checks by different opinions which are essential for safety.

Its disadvantages are: It (1) causes delay in 2. decisions till the meetings are held (2) consumes more time in meetings' (3) may sometimes turn into a trade union meeting if so pulled by the employees. Therefore its good control to the point is necessary.

Types of Committees may be: (1) Main or Central Safety Committee (2) Plant or Shop Safety Committee (3) Technical Safety Committee (4) Special purpose Safety Committee etc.

Technical Safety Committee is useful for specialised knowledge viz. guard design, process and engineering revision, hazard and risk analysis, special investigation etc. It comprises of chief engineer, safety engineer/officer, head mechanic, chief chemist and similar expert technicians.

Special Purpose Safety Committee can be setup for specific jobs and dissolved when its purpose is accomplished. Such jobs include special accident investigation, specific problems of worker behaviour, off-the job safety, rehabilitation or relief problem, safety celebration or contest or award occasions etc.

For a big concern different safety committees as ' stated above are possible, but in a small factory a single committee can carry out all functions.

Size of Committee depends on size of establishment, quantum of unsafe conditions/acts, size and relationship of various departments/units, type of business etc. Workers' representatives should not be less than that of the management.

Its Essential Requirements are: (1) Set-up should be appropriate to the work (Main Committee to include 12 key executives) (2) Members should be well-known and have respect to fellow-members (3) Members must be well aware of working conditions, work methods, practices, hazards, causes of accidents and remedial measures, and (4) It should be as small as possible with minimum members from the sections necessary.

Policy and Procedure: When a committee is formed, written instruction should be issued covering (1) Scope of activities (2) Extent of authorities and (3) Procedure as to time/place of meeting, frequency of meeting, order of business, records to be kept and attendance requirements. The management should make it clear that it wants results and should give effective executive supervision over the affairs of the committee. The committee members should have firm determination to advance the cause of Safety.

Some non-statutory functions are as under:

Functions of Main/ Central Safety Committee arc:

1. To decide safety policy and planning for purchase of equipment with in-built safety devices, relationship between departments standards to be followed in guarding, testing designing, layout, housekeeping, material handling and placing, inspections, accident investigation and records etc.
2. To plan and supervise programmes of safety propaganda, education, training and maintaining interest of employees in safety.
3. To make arrangement or develop safe work practices and procedures; inspection, audit and appraisal systems and all efforts to avoid or reduce accidents. To discuss and control the accident rates.
4. To discuss and initiate action for correction of unsafe conditions and actions. Action plan should be drawn and suitable dates fixed for completion of each task.
5. To suggest safety devices and protective equipment.
6. To carry out fire drill and rehearsal of on-site emergency plan.
7. To scrutinise safety suggestions received through plant safety committees and to initiate action to implement the accepted suggestions.
8. To arrange safety competitions and to decide awards for encouragement.
9. To improve co-operative spirit between management and employees and among various departments to promote safety .

10. The safety knowledge of committee members should be increased by arranging lectures of safety experts of the plant and outside and by sending the members to seminars. Factories inspectors and safety specialists can be utilised for this purpose.
11. To discuss and approve safety budget.
12. To discuss, distribute and supervise responsibilities for quick compliance of safety remarks.
13. To suggests changes in safety organisation and its activities for better performance.
14. To suggests safety aspects of new design and construction of plant, machinery and equipment and
15. To decide disciplinary procedures and disposal of specific safety problems.

Functions of Plant Safety Committees are:

1. To review accident records.
2. To investigate accidents and to implement corrective actions.
3. To implement directives of the Central Safety Committee.
4. Enforcement of safety rules, procedures an accepted safe practices.
5. To encourage and enforce the use of persona protective equipment.
6. Safety inspection rounds of various shops an< sections.
7. To encourage safety suggestions from worker and to forward them to the Central Safety Committee.

11.3.2 Workers' and Union's Participation :

Equal number of safety representatives from workers (or their union) and management should constitute their joint safety committee. This may be a central one or different in different plants. All must be sincere in their desire to co-operate in the matters of safety. Scope of the activities and agreement should be limited to Safety. Union representatives should be selected from the basis of their safety knowledge, interest and experience and should be cooperative and sincere. They should not bring other union demands like bargaining, grievance setting etc. in the meeting of safety committee. Union must recognise management's right of leadership in a joint safety programme. Accident prevention is an area of mutual interest and not of dispute or quarrel. Therefore the workers or union must participate to show their abilities in this area and thus strengthening their relationship with the management and saving their own lives from accidents.

Central Board for Workers' Education, Ministry 'of Labour, Govt. of India runs many schemes for workers' education and training such as (1) Tripartite scheme (2) A worker to worker training scheme (3) Voluntary scheme (4) Need based education (5) Education Officer's training programme (6) Worker Teacher’s training programme (7) Workers' training programme etc. In Gujarat the first workers' education I centre was established in 1967 with the co-operation of the State Govt, employers and trade unions.

The Central Labour Institute at Bombay, Gandhi V- Labour Institute at Ahmedabad and some trade unions also run such education and training classes for workers. All such efforts should increase workers' participation in safety.

See Part 6.7 also.

11.3.3 Supervisor's Safety Contact :

In foregoing Part 6.5 of this Chapter, role of the supervisors is explained at length. By their key position between workers and management and by their constant contact with workers they can easily and effectively promote workers' participation in safety. The supervisor should always try to get such participation. A critical incident technique explained in Part 1.11 and -1.12 of Chapter-19 is based on such safety contacts of plant people. Safety contact by safety manager, safety engineer/officer is also useful.

11.3.4 Safety Suggestion Scheme :

This is an old practice to invite safety suggestion for improvement in process, method, equipment, safety meetings, contests, inspection procedure etc. Criticisms should be replied in the plant magazine or on the notice board to provoke further suggestions and ideas. For suggestion scheme to be successful it is advisable that the employees' effort must be acknowledged, even if the suggestion is not adopted. It must be given careful consideration. Good suggestions should be rewarded among others to encourage them to participate. Written suggestions are the best, but, the oral or telephonic should also be allowed. Sometimes a contest of submitting good suggestions provides useful information and stimulates such effort. This system is effectively accepted by Japanese management. Boxes and forms can also be used to collect suggestions.

11.3.5 Safety Competitions:

This is another method of workers' participation in safety. Competitions (contests) are of two types: (1) Individual comparison - where individual worker takes part in competition and award is given by comparing individual performance. Examples are safety speech or quiz, essay, poem or slogan writing, posters or cartoons etc. (2) Group comparison - where groups take part in competition and award is given by comparing group versus group. Examples are department wise housekeeping competition.

11.3.6 Safety Incentive Schemes :

(i) Financial Incentive:

Financial reward to the most useful suggestion or activity in safety is the commonest method. Other financial incentives should also be given for suggestion to solve particular safety problem of plant or process, machine or equipment etc. Suggestion of good design for a guard or safety device should always be rewarded by handsome amount.

(ii) Non-Financial Incentives:

Award for safety performance, trophy, memento, certificate of merit, public honour, praise or pride, awarding special safety hat or kit or symbol of recognition, awarding special status and duties of safety work, giving special position such as honorary member of safety committee, raising the cadre or post, giving extra designation for any remarkable safety contribution are all examples of non-financial incentives.

These non-financial incentives are self preservation, personal and material gain, loyalty, responsibility, pride, conformity, rivalry, leadership, logic and humanity. If these incentives are properly utilised they help much in accident prevention work.

Safety performance (frequency and severity rates) of different groups can be compared for the same period. Here groups are motivated for competition. Similarly factories can be invited for contest if district, state or nation-wide competition is arranged. State and National Safety Councils do this. Every year safety competitions are held among similar class of factories to boost up safety activities and group motivation.

In any type of safety contest the rules of contest and comparison must be well defined, declared beforehand and fair and reasonable to all participants. Scoring system should be simple or easy to understand. Winners may get shield, certificate or good prize but non-winning participants should also be compensated for encouragement. The competition movement as a whole should be encouraged as this effort itself is most important. Care should be taken to avoid any discredit. Cheating or malpractice like compelling an injured worker to continue work to show less man-days lost, shall be disregarded. Similarly false reporting of safety figures should also be avoided. Competition should be fair and fine and fitting to its noble cause.

Safety Quiz is one type of safety competition or contest. It can be conducted by asking questions to participants or by giving them an objective question paper containing quiz questions to be answered in a stipulated time. It touches wide area of safety in short time and participation looks live.

11.3.7 Audio-Visual Publicity :

As we saw in foregoing Part 10.7 of this Chapter, a trainee tends to remember 50% of what he sees and hears and 70% of what he sees and talks. This is possible by audio visual aid only. Television and video effectively reproduce actual happening. Therefore safety education and training by safety films on TV is the most powerful method. Only difficulty is in getting safely films or safety video cassette easily and frequently. This should be made possible if we wish to utilise its full role in increasing safety.

Slides, filmstrips and transparencies are easily available or prepared and therefore they should be used to die extent possible to hold the picture to discuss and understand it in details which is not possible with a moving film.

Modern media is a closed circuit television. Travelling units are complete television studios in themselves and have up-to-date equipment with the control room housed in a single vehicle. There are fixed and moving cameras, telecine equipment, a video tap recorder and monitor screens which can be installed up to 500 meter away from the studio. Using both inside and outside cameras, extensive safety programmes can be broadcast through the closed network. Such unit can be hired also.

11.3.8 Other Promotional Methods :

Other promotional teaching methods for employees' participation are safety posters, cartoons, signs and slogans, publications, booklets, bulletin boards, safety contests and rewards, counselling of education and training, demonstration, safety meetings, safety campaigns and stunts, first-aid training, fire brigades, safety- inventory or questionnaire, accident investigation, inspection, job safety analysis etc.

12 APPROACHES TO COMPLIANCE & VIOLATIONS:

12.1 Approaches to Compliance

All rules are for compliance. Rules on paper are no rules. Rules in effect are real rules. Strict and quick compliance of safety rules is most desirable. Poor or no compliance goes against safety. No compliance of statutory provisions may bring dire consequences. Loss of various types results in decreasing productivity. Therefore measures for compliance of safety rules must be adopted whole-heartedly.

Responsibility for compliance should be fixed and so divided that the compliance is achieved and reported within stipulated time. Action for compliance should be started at once and interim reply should be given if the action is still continued. Probable time for completion should also be reported.

Defending delay or avoiding compliance is of no, use. Effective measures for speedy compliance should be determined and applied. Preventive and corrective maintenance, trained team, sufficient spares and tools, ready procedure, drawing, charts, tables, extra equipment and safety devices are good measures for' quick compliance.

The measures may vary according to the matters to be compiled. Quick decision for selection of measures for compliance is equally important.

When some rules are not, compiled their reasons must be considered. The reason may be fault with rules, employees or supervisors. Such fault should be detected, studied and removed to achieve compliance.

12.2 Approaches to Violations:

Violation of safety rules must first be detected and removed. Violation may result in accident and economic losses. It must be prevented. Rules are made for non-violation. Therefore no violation should take place.

However if it takes place, it should be studied and its reason should be removed. Violation of statutory rules may result in prosecution and compensation. Despite of this legal proceeding it adversely affects health and safety of work people.

Violation of non-statutory internal rules calls for disciplinary action. If such corrective action is not taken, the rule ceases to exist. First correction is to teach the requisite measure for compliance so that the mistake is realised and action is soon taken for non-recurrence.

If repeated violation is noticed, some appropriate punishment may be necessary. Only punishment will not serve the purpose, as solution of unsafe behaviour is not any admonition or penalty. Anyhow requisite safe behaviour must be reflected and that is the real solution.

Normally the approach to violation of a safety rule should be to detect and remove the cause and not to find and punish a wrong doer.

E X E R C I S E

1. Comment on following explaining it is True or False:

1. The oldest views on 'management' found in ancient India are well explained.
2. Elements and principles of management are the same.
3. Safety management in industry is evitable.
4. Leadership is not essential in safety management.
5. Trade union's role in safety management should be co-operative with the management.
6. MGO can function better than the Government organization in the field of safety.
7. Training for safety is a waste of money.
8. Methods and types of training are the same.
9. Workers are reluctant to participate in a safely programme.
10. Approach to violation of safety rules is to find and punish a wrong-doer.
11. Supervisors should not be blamed for accidents.
12. Human Resource (personnel) aspect is equally important as the material resource aspect in safety management.
13. Supervisor is a key person in any safety programme.
14. Management should take leadership in safety.
15. Safely committees are usually not effective.
16. Safety is the line responsibility and staff functions.

17. Management's 'involvement' is more important than its 'support' in safety.
18. Trade unions have to play a vital role in the interest of safely.
19. Supervisor is a link between management and the workers.
20. Management is more responsible than workers for safety.

2. Write Short Notes on:

1. Old Indian concept of Management.
2. Old foreign concept of Management.
3. Definition of 'Safety management.
4. Nature of management.
5. Seven elements of management.
6. Types of management.
7. Span of management.
8. Planning for safety.
9. Definition and areas of 'Safety planning'.
10. 'Planning premises' for safety.
11. MBO OR MBE.
12. General definition and types of organization.
13. Definition and need of safety organization.
14. Techniques of direction.
15. Leadership styles.
16. Process of communication.
17. Barriers of communication.
18. Group dynamics OR Two-way communications.
19. Safety policy OR Purchasing policy.
20. Role of safety organizations in Gujarat OR Elements of a training cycle.
21. Duties of a Safety Officer.
22. Attitudes of a Safety Officer.
23. Objectives of Safety training.
24. Modern methods of training safety training.
25. Kinds of supervisory problems.
26. Benefits of training programme.
27. Safety committee.
28. Reasons of failure of safety committee.
29. Steps to revive the usefulness of safety committee.
30. Safety suggestion scheme.
31. Safety competition or contest.
32. Psychological safety rules.

3. Explain, State, Narrate or Describe in detail:

1. Evaluation of Management thoughts OR Thoughts of scientific management.
2. General definitions (any three) of management
3. Elements of management functions.
4. General principles of management.
5. Strategic planning.
6. Role of MBO in safety.
7. Role and functions of a leader OR Attributes of a leader.
8. Definition and purpose of communication.
9. Essential of effective communication.
10. Definition and steps of controlling.
11. Statutory duties of Safety Management.
12. Role of Supervisors in safety.

13. Role of Workers in safety.
14. Role of Trade union in safety.
15. Role of Competent persons in safety.
16. Role of Safety specialists or Professionals.
17. Role of the Government in safety.
18. Size, Status and Functions of Safety department
19. What do you mean by a Safely programme? What could be the areas of such programme?
20. The steps of training process.
21. How will you assess the training needs? OR How will you integrate safety training with job training?
22. Methods of training OR Types of training.
23. You are a Safety Officer. You have to plan a training programme for new workers. State in brief what topics you will include.
24. Narrate the content of a training programme for safety supervisors.
25. What are the indicators of a successful training programme?
26. State areas of participation by workers OR their duties and functions.
27. State various methods of participation in safety activity of a factory.
28. Explain the functions of a safety committee.
29. Explain the needs for safety rules, procedures, codes etc.
30. What should be the criteria to formulate safety rules?

4. State the Difference between:

1. Authority and Responsibility
2. Authority and Power
3. Tall and Flat structure of management.
4. Delegation and Authority
5. Delegation and decentralisation of Authority.
6. Directing and Co-ordinating.
7. General planning and Strategic planning.
8. Formal and Informal communication.
9. Oral and Written communication.
10. Role of a Competent person and that of a Safety Professional (specialist).
11. Safety education and training.
12. On the job and off the job training.
13. Individual v/s mass training.
14. Safety policy and safety committee.
15. Financial and non-financial incentives for safety.
16. Statutory and non-statutory safety rules.

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CHAPTER – 7

Plant Siting and Safe Design

THEME

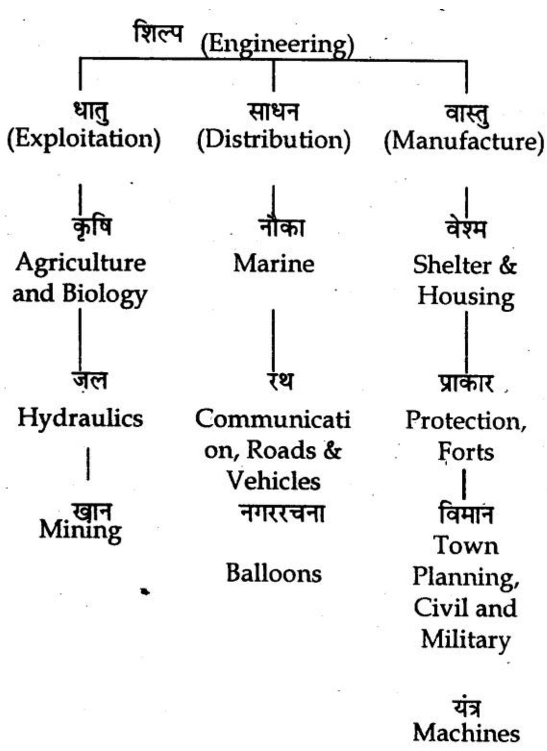
1 INDIAN HERITAGE

When we look at the old Indian structures and architectures which still exist, really we surprise. Without the aid of modern engineering drawing, techniques, lifting and shifting machines, our forefathers had designed and constructed such an amazing architecture which was unparallel not only in that time but also in present era.

Various temples, forts, step-wells; etc., on mountains and in towns, Tajmahal and leaning towers, varieties of monuments and antiquities, sculptures, incarnation, places and havelies of aesthetic and historical value are some of the glorying examples of our cultural heritage and archaeological wealth. List of sites and details can be had from the Department of Archaeology. We were ahead in the world in safe design, layout and construction of structures of those days. A remark of Claude Batley, A.R.I.B.A. F.I.I.A. describes as under:

"The great heritage of Indian architecture has been neglected and many modern buildings are exotics unfit to exist in India's climates, under its often vertical sunlight and its monsoon winds and rains. The essential of Indian traditional architecture are : The stone plinth, the thick walls, the window openings extending to the floor so that the air may circulate freely, the internal courtyard, the caves, the terraced roof. **Above all, planning was employed to increase the health and amenities of the community."**

According to Hk`xq f'kYi lafgrk (Some 1000 years BC), 'kqØuhfr v/;k; & 4 and page 20, izkphu fgUnh f'kYi'kkL= Hkkx &1] iquk 1928] Bharatiya Schools of Engineering are as under:



There were 75 sub-branches of above main branches of engineering.

As published by Rao Sahib K.V. Vaze, LCE, Bombay, PWD, in Vedic Magazine, Lahore, January 1924 main ten branches of Bharatiya Engineering were as follows :

1. d`f"k'kkL= Propagation, agriculture, biology etc.
2. ty'kkL= Imsrrm Hydraulics.
3. [kfut'kkL= Mines and minerals, stones, metals etc.
4. ukSdk'kkL= Navigation, boats, playing in rivers, tank, sea etc.
5. jFkk'kkL= Construction of roads, vehicles, carts etc.
6. vfXu;ku'kkL= Aeronautics.
7. okLrq'kkL= Building construction, houses etc.
8. izkdkj'kkL= Defensive workes, fort, trenches, protection etc.
9. uxjpuk'kkL= Town planning.
10. ;a='kkL= Machines, Mechanics etc.

Qualities of an engineer (LFkifr) are described in e;er v/;k; & 5 izkphu fgUnh f'kYi'kkL=] Hkkx&1 as under.

LFkifr% LFkkiukgZ%L;kr~ loZ'kkL=fo'kkjn% A
u ghukaxksfrfjDrkaxks /kkfeZd'p n;kij% AA

vekRl;ksulw;'p rkaf=dLRofHktkroku~ A
xf.krK% iqjk.kK% lR;oknh ftrsafn+;% AA

fp=Kks ns'kdkyK'pkUun'pkI;yqC/kd % A
vjksxh pkizeknh p llrO;luoftZr% AA

An Engineer should be fully qualified and capable of doing all types of construction work. None of his body parts should lie defective or excessively short or long. He should be practitioner of Dharm, benevolent, unmistaken, active, mechanic, healthy, tolerant toward others' progress, mathematician, historian, truthfully and self controlling. He should be well conversant with drawing, design, time, weather and meteorology. He should be free from disease, laziness and seven evils of greediness, intoxication, gambling etc.

A book Indian Sciences and Scientists' by N.K. Jain, Delhi, throws much light on our ancient advancement in many faculties of science, engineering, medicine, surgery etc. Nalanda and Takshshila were the world famous universities where even foreign students were also learning. Hu-en-Chang of China was one of them.

Now let us see the current provisions for constructing a factory.

2 STATUTORY REQUIREMENTS UNDER. THE FACTORIES ACT & THE G JARAT FACTORIES RULES :

Following arc some useful points for design, layout and construction of a factory and preparing plans for the purposes of the Factories Act and Rules. The plans are to be submitted to the concerned Factory Inspection Office. Plans are required u/s 6 of the Factories Act 1948 and. u/r 3 & 3B of the Gujarat Factories Rules 1963. Following details must be considered at the initial (design) stage of preparing plans.

In following parts, 'sec' means section of the Factories Act 1948 and 'rule' means rule of the Gujarat Factories Rules 1963.

2.1 Points at Drawing (Blue-print) Stage :

Rule 3B states that plans of the factory drawings should be drawn to scale and should include factory site, surrounding buildings, roads, drainage etc., plan, elevation and cross sections of the buildings showing lighting, ventilation, means of escape, plant and machinery layout, aisles, passage ways etc.

Rule 3C requires drawings for every work of engineering construction i.e. any building, tank, silo, scaffold, platform, chimney, bridge, supporting structure, retaining wall or any similar structure.

After approval of such drawings, a Stability Certificate in Form No. IA is to be obtained from a Competent Person recognised u/r 2A by the Chief Inspector of Factories and should be submitted to the Factory Inspection Office. Fresh certificate is required after each period of 5 years or after every extension, alteration, repairs, or addition of machinery, plants etc. Manufacturing process cannot be started if such certificate is not obtained and sent to the CIF.

Only applicable requirements should be furnished. All attachments should be in duplicate, signed and stamped by the Occupier of the factory and in order. All drawings should have been to proper scale and with north direction shown. Proposed construction / alteration / arrangements should be shown in red and that to be removed in yellow. Factory boundary should be shown in green including all its premises and precincts therein.

All figures, dimensions, specifications, distances and necessary schedules of doors, windows, machinery and equipment should be shown on plans at proper places. The requirements are as follows :

1. Plans in ammonia(blue) or modern prints (white with black lines) showing details of site ' (location), all buildings and machinery layout including lifting machines,- pressure plants, storage & process vessels, godowns, warehouses, stores, furnaces, means of access, stairs, floor openings, pits, reservoirs, sumps, tanks, boiler house, coal yard, generator room, effluent treatment plant, mess room, water facilities, etc., workshops, canteen, rest-lunch room, creche, cloak-room, first-aid or ambulance room, drinking water centres, latrines, urinals, washing places, spittoons, fire protections, emergency control room, locations of FEE & PEE, tools & transport equipment, means to remove heat, dust, fume, vapour, smoke, gases, airborne contaminants, radioactive waste etc., adequate lighting, ventilation, temperature and noise control; necessary elevations, end-views, cross-sections showing roof design and other details and all safety measures to be provided.

2. Certificate from local authority viz. Gram Panchayat, Nagar Palika, Municipality, I Corporation, Industrial Estate, Urban Development Authority, Collector etc. regarding permission for the site of the factory.

3. Form No. I, GFR, duly filled in with necessary enclosures.

4. Annexure-7 u/r 68J, GFR, and u/r 7(1), MSIHC Rules, in case of a hazardous factory.

5. Annexures 8 to 10 u/r 10(1), 17 and 18(5) of the MSIHC Rules, 1989, in case of hazardous chemicals or/and MAH factory.

6. Stability certificate from a Competent Person in Form IA to be submitted before starting a factory.

7. List of raw materials with their storage quantities and parameters.

8. List of products (including by-products) with their production capacities.

9. Process flow chart and description of manufacturing process in brief.

10. List of machinery with their Horse Powers and other capacities.

11. MSDS and safety manual in case of chemical factories, and information required by the Site Appraisal Committee u/s 41A, if such Committee exists.

12. Details of safety fittings, equipment, tools, devices and measures to be adopted with the list of protective wears and fire protection to be provided.

13. Details of fire water reservoir, pumps, suction, hydrants, fixed fire installations, control valves etc.

14. Copy of the last site plan and plan-approval letter from the Chief Inspector of Factories, in Case of plans for extension / alteration of the factory.

15. Copy of approval from or application to the State Pollution Control Board in case of factories polluting land/water/air.

16. Copy of approval from or application to the Explosive Dept. in case of factories using/ manufacturing explosive substances.

17. Copy of approval from or application to the Prohibition Dept. in case of factories using/ manufacturing prohibited substances.

18. Load-bearing calculations for the stability m the structure.

19. Any other information required by the Factory Inspection Office.

20. A forwarding (covering) letter mentioning which items from the above (1) to (18) is submitted therewith.

Minimum Dimentions :

(A) Roof Heights (minimum required):

For RCC Slab/Tiles/False Ceiling	-	12’ or 3.7 M
AC Sheet	-	16’ or 4.9 M
GI Sheet	-	18’ or 5.5 M

To prevent fall accidents, it is highly essential to use unbreakable metal sheet instead of a fragile AC sheet as roofing. Now a days, reinforced plastic sheets are available against the normal fragile AC sheets. Fragile AC sheets are unsafe as they have caused many fatal (fall) accidents.

Minimum roof height for Canteen, Shelter, Rest room. Lunch room and Creche - 12' or 3.7 M. (B)

(B) Other Dimensions (minimum required):

1. Work Room area (Sq.M) $\geq$

$$\frac{\text{(No. of Workers in the room x 14.2) + Volume in cub m. of machineries in the room}}{\text{Height of roof in m. (Consider max. 4.2 m only)}}$$

2. Sanitary Blocks (Sec. 19 & 42)

Latrines	-	16 SF or 1.5 SM
Urinals	-	12 SF or 1.1SM
Bathrooms	-	24 SF or 2.2 SM
No. of Latrines	-	As per Rule 41, GFR
For Females	-	1 per 25 females
For males	-	1 per 25 up to 100
	-	1 per 50 thereafter.
No. of Urinals	-	As per Rule 45
For males	-	1 per 50 up to 500
	-	1 per 100 thereafter.

No. of Bathrooms/Washing Places - As per Rule 68W, 69 and 102, GFR.

No. of Taps - 1 per 15 workers or as per Schedule in the Rule. At least 27.3 litres water per worker per day is necessary.

Note : Latrines and urinals should not open in work-room. Bath-rooms should not be in the vicinity of latrines and urinals. There should be separate latrines and bathrooms for males and females maintaining privacy and sign boards. Requirements of Sec. 19 and Rule 41 to 50 should be fulfilled.

3. **Ventilating Openings** in a workroom (Rule 18A): = 15% of the floor area (min).

4. **Quantity of fresh air** by mechanical means (Rule 18A): == 6 x workroom volume (M^3) per hour

5. **Thermometer height** (Rule 18A) : = 1.5 m- from the floor.

6. **Spittoon Stand** (bracket) height (Rule 51) = 0.914 m. or 3 ft from the floor.

7. **Cloak-rooms :** Necessary for the factories in Schedule u/r 69-A and 102. It is advisable to have separate cloak rooms for males and females.

8. Ambulance room : (Applicable for workers 500 or more) As per Sec 45 and Rule 71.

   Minimum Area necessary - 250 SF or 24 SM

   It should contain items mentioned in Rule 71(3).

9. **Canteen** (applicable for workers 250 or more) As per Sec 46 and Rule 72 & 73.

   Minimum height - 12 ft. or 3.7 mt.
   Minimum Area for dining hall = 1 SM or 11 SF per worker of 30% of workers working at a time. (Area occupied by service counter and furniture except tables and chairs should be excluded).
   Canteen should be at least 50 ft or 15.2 m. away from latrine, urinal, boiler house, coal stacks, ash dumps etc.

10. **Shelter, Rest rooms & Lunch rooms** (Applicable for workers 150 or more) Sec 47 and Rule 79. Minimum Area = 1 SM or 11 SF per worker.

11. **Creche** (Applicable for 30 female workers or more) As per Sec 48 and Rule 80 & 81 Minimum area = 2 SM or 22 SF per child.

12. **Special provisions u/r 102, Schedules for Dangerous Operations :**
    1. Air space per worker in a room > 14.2 m^3 or 500 ft^3 where height over 3.7 m. or 12 ft shall not be accounted.
    2. Pasting distance and rack/shelf size - as per Sch. 3
    3. Washing facilities : Spacing 61 to 120 cm between two workers or water pipes, .Pipe height = 2.1 m, dia == 2.5 cm.
    4. Mess room size = 0.9 m^2 per worker, height 3.7 m or more
    5. Vessel fencing : Height 91.4 cm. or 3 ft
    6. Plank or gang-way width = 45.7 cm.
    7. Toxic or flammable solvents : Two exits in each room. Two means of escape from the building. Doors should open outward.

13. **Cotton Textile, Ginning, Wood-working and Rubber Mills, Centrifugal m/c. Power press, Shears, Slitters and Guillotine m/c.** As per Rule 54.

14. **Hoists / Lifts / Lifting Machines**. As per Sec 28, 29 and Rules 59, 60 & 60A.

15. **Pressure Plants.**
As per Sec 31 and Rule 61.

16. **Floors, Stairs and Means of Access.**
As per Sec 32, 38 and Rule 66, 67.
Minimum width of fire exit 3' or 0.91 m. and minimum height 6.6' or 2m. as per Rule 66(l)(b). One or two separate stairs necessary as per Rule 66 (l)(c) or (d). All means of access should be shown clearly.

17. **Minimum Dimensions of Manholes :** As per Rule 64.
Size : 0.41 m x 0.31 m or 1.35' x 1.0' or 0.41 m or 1.35' diameter.

18. **Machine Distances ;** Normally a distance of 3' or 1m should be kepi between a machine and the nearest machine or a fixed structure (e.g. wall).

19. **Dimensions of Fire Exits (Rule 66A)**
An exit includes doorway, corridor and passageway but does not include lifts, escalators and revolving doors. The exit should provide continuous (unobstructed) and safe egress (departure) by fire resisting wall. See item 9 (24 points) in Part 3.1 of Chapter-13 for fire exits specifications.

20. **Storage of Material (Rule 66A) :**

    1. Passage width between two piles > 90 cm.
    2. Clearance between ceiling and the pile top > 2 m.
    3. Safe distance in heaps of flammable material. Open ground storage at minimum distance of 10m from process or storage building.
    4. Gas cylinders should be away from highly flammable substances, furnaces and hot processes. Roof and adequate ventilation are necessary.

21. **Location of Fire Extinguishers (Rule 66A):**
750 mm above the floor level.

22. **Explosion Panels (Rule 68G) :**
Size 2200 cm2 per I m-" volume of the oven/drier.

23. **Ship ladders or sound Gangways (Rule 68H):** Width > 55 cm, each side railing 90 cm. ht.

24. **Wash tank of clean water in electrolytic Plating Works (Rule 102, Sch. 2)** :
Size 1500 Litres.
Washing space between two workers 1.2 m.

25. **Solvent Extraction Plant (Rule 102, Sch. 21)**
    1. Plant 30 m away from the nearest locality.
    2. 1.5m high fencing at a distance of 15 m from the plant.
    3. Boiler House etc., at a distance of 30 m or more from the plant.
    4. If any construction or process is within 30 m from the plant, barrier wall of noncombustible material and 1.5 m high at a distance of 15 m from the plant.
    5. No solvent 'shall be stored in plant building. Space of 15 m within the plant shall be kept free from combustible material.

26. **Pottery Works (Rule 102 Sch 25) :**
    1. Mess room size 0.93 m2 (minimum)

2. Water stand spacing 1.2 m. (minimum)

27. **Foundry Works (Rule 102, Sch 26) :**

1. Gangway width
   If not used to carry molten metal - 0.92 m.
   If used to carry molten metal -0.6m to 1.8m as prescribed.
2. Pouring aisle width - 0.46 m to 0.76 m as prescribed.
3. Safety distance - 4 m from the delivery spout, or 2.4 m from ladle.
4. Wash stand spacing - 1.2 m.

Note : Details of I to 27 above should be shown in the plans. It will highlight the points of legally safe design.

2.2 Cleanliness and Good Housekeeping :

Sec. II, 20 and Rules 16 to 17 A and 51 to 53 deal with this subject. Where a floor is liable to become wet due to manufacturing process, effective means of drainage should be provided.

Effective means of keeping the factory (including compound) clean by washing, sweeping, brushing, dust or vacuum cleaning should be provided. White washing, colour washing, varnishing, painting etc., should be carried out as in Sec II (l)(d) except in factories exempted u/r 16.

Spittoons should be provided in convenient places on a stand/bracket 3' or 0.91 m high in a clean and hygienic condition.

Good housekeeping is a wider term than cleanliness. It includes in its sphere orderly plant and machinery layout, storage, interior arrangements, equipment, floors, drains, pits and manholes, stairs and platforms, sanitation and ventilation, colour, illumination and electric fittings, fire extinguishing system, yard areas and compound, safety and first-aid, display of notices and instructions, and identification and removal of hazards. Good housekeeping helps in increasing productivity and in decreasing accidents and fatigue in workers. .

For details see Chapter-8.

2.3 Disposal of Effluent and Air Emissions ;

Sec. 12 & Rule 18 deal with this subject.

To connect drainage system of a factory with public sewerage system, permission of local authorit and for other mode of disposal, permission from Health Officer is required.

Three Central Acts (1) Water (Prevention & Control of Pollution) Act 1974 (2) Air (Prevention e Control of Pollution) Act 1981 and (3) Environment (Protection) Act, 1986 are administered by Central and State Pollution Control Boards. Therefore, their approval/consent is also necessary for disposal of effluent and air emissions. For details see Part 10.1 to 10.15 of Chaoter-28

Various Indian Standards are prescribed for tolerance limits of many characteristics of effluents and sewage to be disposed. For details see Part 10.6 of Chapter-28 and Tables II to 14 of Chapter-32.

Pre-treatment, storage or equalisation tank, primary treatment, secondary or biological treatment and tertiary treatment are the treatment methods generally employed in sequence. An incinerator is used to burn the solid or liquid waste. After testing the effluent sample, appropriate method should be selected. See Table 16 of Chapter-32.

Method for disposal of contaminated air/gas should also be selected. Description of method for effluent disposal and tolerance limits to be achieved after treatment should be submitted along with the plans.

For details see Chapter-18.

2.4 Ventilation, Temperature, Dust, Fumes etc.

Sec. 13 to 16, 36, 37 and Rules 18A, 19 to 29, 64, 65 and 102 deal with this subject.

Ventilation is necessary to remove excessive temperature, contaminants and carbon dioxide exhausted and to supply oxygen or fresh air in work places.

Factors affecting are: (1) Temperature of air in room (2) Air velocity (3) Temperature difference between inside and outside of rooms (4) Heat radiation (5) Humidity and (6) Clothing of the workers.

Room temperature @30 °C (80 °F), Air velocity @30 mt/min and Temperature difference @2 "C (3.6 °F), are comfortable. Decrease or increase in these limits may cause discomfort. Site (place), season, surroundings etc. may vary the limits.

Types of ventilation are (1) Natural and (2) Mechanical. Natural ventilation is the cheapest ventilation. Therefore, try .to minimise the walls, and partitions. Increase doors and windows. About 15% of floor area should be provided for natural ventilation. Select proper type of roof/false ceiling and cross ventilation. More open space should be provided in chemical and dangerous plants.

Up to a room of 60' or 18 m length or width sufficient natural ventilation should be provided but for an area greater than this mechanical or forced or local exhaust ventilation is necessary.

Exhaust fans. Man-cooler fans (throwing air on man). Hood, duct and blower. Air cleaning device. Air cooling (passing air through water) devices. Air-conditioners etc. are used as means of mechanical ventilation. This system may be of forced draft or induced draft (capture) type or Low volume High Velocity (LVHV) type. Proper design should be selected. Heat insulations like aluminium screen near furnace, lagging and cladding on pipes and valves etc. are also useful.

Height, type and material of roof and walls, separation of hot processes or parts, exhaust appliance near the point of origin of dust, fume, impurity etc., Hood & Chimney, Humidity control (S 15 & R 19 to 29), 500 cu. ft. or 14.2 cu. m. of space per worker (considering height upto 14' or 4.2 m only), manhole of prescribed size, precautions against dangerous fumes (S 36). Portable electric light (S 36A) and inflammable dust, gas etc. (S 37 and exemption u/r 65) should be adopted as per statutory provisions.

For details see Chapter-10.

2.5 Lighting and Colour:

Sec. II, 17, 35 and Rule 16, 30 to 34 and 63 deal with this subject. Sec. II (1) (d) requires that particular parts of a factory should be white washed, colour washed, varnished or painted in prescribed periods. Rule 16 states exemption to this.

Sec. 17 requires sufficient and suitable lighting, natural or artificial or both and prevention of glare and shadows.

Rule 31 describes standards of lighting (illumination) over interior parts of a factory in general and of a ginning factory in particular. Rule 32 describes measurements for prevention of glare. Rule 30, 33 and 34 are exempting rules to this lighting provisions. The schedule u/r 34 gives a list of exempted factories. Sec. 35 (b) and Rule 63 (b) requires protection of eyes from exposure to excessive light. Effective screens should be provided for welding, cutting and melting processes creating excessive light.

IS:6060 and IS:6665 prescribe lighting standards.

Artificial light is costlier than natural or day light. Their combination is known as "Twilight" which is frequently used in offices.

Lighting may be of four types

1. Direct or local lighting - on particular job or working.
2. Indirect lighting - through reflection.
3. Combination of direct land indirect lighting, and
4. Diffused lighting through shade (fixture) surrounding lamp.

Lamps near machines or job and portable lamps must have shades or shields. Light should also go to ceiling. Indirect and diffused light is desirable than direct light. Unwanted reflection should be directed away from eyes. Work tables, chairs etc., should be so placed that light from windows comes from sides.

Flameproof lighting should be provided in flammable areas.

Lamps are of three types - incandescent filament, tubular fluorescent and colour corrected mercury vapour lamps. They have different light qualities. Lighting fittings are also of various types. Proper selection is necessary.

Colour code is also important. White and light colours give more reflections of light than that by black and dark colours. Ceilings should be white or near white. Walls should have light colours like yellow, green etc. Floors may have dark colours, but not white as it may create glare by upward reflection of light. Shining aluminium colours on walls are not good as they may also cause glare. Furniture and equipment may have medium colours.

Different colours are used for safety precautions and as accident prevention signs. Colours on pipes are useful to distinguish them. Guards should be regarded as part of the machines and should be painted in the same colour as that of the machine. If they are to be distigvished bydifferent colour, it should not be too dark. Colours on machines/vessels should be light, cool and pleasant.

For Details see Chapter-9.

2.6 Drinking Water:

Sec. 18 and Rule 35 to 40 deal with this subject.

Drinking water centres (with such written boards) should be' provided at suitable points conveniently situated for all workers. They should not be within 20' or 6m from any washing place, urinal or latrine.

Quantity of drinking water should be 4.5 litres per worker per day. Water should be clean and readily available during working hours. Proper storage with cover is also necessary. It should be cleaned and renewed every day. Report from Health Officer is reuired.

In a factory employing 250 workers or mole, cooled drinking water should be supplied from March to November each year. Each floor should have one water centre and one centre per 150 workers up to 450 and one per 450 thereafter. Each centre should have 3 or more taps (fountains) at least 2' or 0.6 m apart, and shall have a trough to drain away the split water. A person with clean cloths to distribute water is necessary. For details see Rule 40.

All water centres and their distances should be shown clearly in plans.

2.7 Material Handling:

Sec. 28, 29, 34 and Rule 58 to 60A and 62 deal with this subject. Material handling means the techniques used to move, lift, shift, transport, store or distribute materials with or without the aid of mechanical appliances.

As per one old study, about 40% accidents, 36% production cost and 66% process time cycles are due to material handling. Automation may help to reduce these figures. It is of two types (1) Manual handling and (2) Mechanical handling.

Manual handling is carried out by persons alone or in group (team) or/and with the help of hooks, crow-bars, rollers, hand trucks (carts), wheel barrows etc. Methods of lifting and habits play an important role.

Mechanical handling is carried out by hoists, lifts and 'lifting machines' like overhead travelling crane, jib crane, crab winch, teagel, pulley block, gin wheel, transporter including power trucks and conveyors or runway and with the use of "lifting tackle" like chain slings, rope slings, rings, hooks, shackles and swivels.

All rails, tracks and passage-ways for all hoists, lifts and travelling cranes should be shown in plans with their layout, height, distance, railing or guarding and capacities.

For details see Chapter-15.

2.8 Pressure Plants:

Sec. 31 and Rule 61 deal with this subject.

Pressure plant means a' plant, machinery, vessels, air receivers, digesters, petroleum stills, Vulcanisers, sterilizers, kiers or equipment used in manufacturing process and operating at a pressure above atmospheric pressure and includes water sealed gas holder having a storage capacity of 5000 cu. ft. or 141.5 cu. m. but it does not include working cylinders of prime movers (i.e. engines), gas cylinders, Other vessels exempted u/r 61 and vessels under the Boilers Act, 1923.

All pressure vessels including reaction vessels and sizing cylinders with all fittings should be shown in plans indicating their height, distance, surrounding and capacities. Means of safety and escape near such plant should also be shown. A schedule indicating number and size/ capacity of safety valve, pressure gauge, stop valve, drain valve, pressure reducing valve, rupture disc., temperature indicator, manhole, inspection window and other safety devices should be given.

Effective measures should be provided to ensure that the safe working pressure will never exceed.

For details see Parts 9.1.5 & 15.5.1 of Chapter-18.

2.9 Fire Protection

Sec. 38, Rule 66, 66A and 67 deal with this subject.

Fire causes loss of or damage to person and property both. Therefore preventive and controlling measures for fire are most important. This should include training and regular drill for fire fighting also.

When Heat, Fuel or Oxygen meet, a fire occurs. Therefore try to segregate chances of meeting of these three factors. At the stage of design and planning for a factory, this basic concept should not be ignored. Mark and maintain safety distances.

'Fire Loads' should be calculated by considering total fire danger in the factory. For this, types of materials, their heat capacity, equipment, storage, pressure, temperature, radioactivity, electrical hazards, types of fire etc., are taken into account. Generally Fire Insurance people do this. Then depending upon this fire-load, fire-fighting water quantity and equipment are decided. As per example, if a fire-load is calculated as 40 cu. mt/min., it means, a water spraying capacity of 40 cu. mt/min is required at all fire points. Design for Emergency plan & Disaster plan, in case of heavy fire loads.

IS:2190 suggests suitability of different types of portable fire extinguishers for different classes of fire.

In addition to necessary fire extinguishers, automatic heat, flame or smoke detectors and alarms, fire hydrants, monitors, sprinklers, sprays, hose-reels, risers, drenches etc., are also useful. Provide and mark clearly fire-exits, fire escape stairs, fire warning, fire buckets and no-smoking notices. Utmost care should be taken in chemical factories.

Fire protection layout and schedule of equipment should be shown in plans. Stairway, lift-way and means of access and escape should be of fire resisting materials. Angle of fire escape stair should not be more than 45° from horizontal and it should be available within a distance of 150' or 46 m. along the line of travel for escape. In a ginning factory; two suitable earthen ramps or flights or stairs made of brick work or fire resisting material should be provided (Rule 66 & 67).

For details see Chapter-13.

2.10 Dangerous Operations and Processes :

Sec. 87 and Rule 102 deal with this subject.

Provisions of 27 schedules for 27 dangerous operations/processes under this rule are most important from safety point of view. They should be strictly followed. Applicable details should be submitted along with the plans.

Special fencing of machines and vessels, protective wears, exhaust draft, floor of work-rooms, cautionary notice, play-card, separation of process, air space, ventilation, pasting room, work benches, disposal of dust, gases and fumes, container of dross and lead waste, drying room, mess room, cloak room, washing and bathing facilities, storage and transport, flame-traps, fire extinguishers, escape of petrol, flame proof electrical fittings, blasting enclosure, separating apparatus, first-aid arrangements, mixing and filling with scoop, cocks and valves, manholes, disposal of waste, means of escape, air analysis, medical facilities, housekeeping, process hazards, instruments, protection of reaction mixtures, site, isolation of buildings, fire. resistant construction, dangers of ignition, static electricity, process heating, escape of materials, leakage of flammable liquids, empty containers, storage of combustible materials, pipe lines for inflammable liquids, packing of reaction vessels, vigorous or delayed reactions, examination, testing and repair of plant, alarm system, effluents, staging, entry into vessels, storage of acid-carboys, buildings, drainage, covering of vessels, substitute, enclosed system, protection against inhalation, measures against skin contact, labelling etc. are described in various schedules u/r 102. Necessary provision/arrangements should be shown in plans at proper places.

Schedules No. 12, 19, 20 and some others u/r 102 provide chemical details. First, Second and Third schedules, and Chapter-IVA under the Act regarding hazardous processes, permissible levels of some chemicals in work environment and notifiable diseases must be referred while planning.

Ordinary flooring tiles contain carbonates which react with acid. Therefore acid-resistant flooring is required where acid or alkalis are handled. Alkalis on flooring create slippery surfaces. Water showers should be provided to dilute the effects of acids and alkalis. Storage and handling of solid, liquid and gaseous chemicals should be done carefully. Sources of heat, ignition or spark should be kept away. Dangerous limits including threshold limit values (TLV) should not be exceeded. Auto controls and recorders should be provided to control high pressure, temperature etc., within their limits. Workers should be provided with necessary protective equipment.

A material safety data sheet in respect of each dangerous chemical should be supplied to study properties and hazard potential of chemicals. Preventive/Control measures should also be stated therein.

Air is the breath of life, its absence or contamination may cause death or disease". These contaminants could be dusts, fumes, gases, vapours, mists, fog, smoke, grass etc. Dust may be of silica, coal, asbestos, cotton etc. Methods of prevention are substitution, segregation, enclosures, exhaust ventilation general ventilation including natural and mechanical, wet methods, use of personal protective equipment, personal .cleanliness, warning and publicity, education and training, medical examination etc. Appropriate neutraliser/scrubber, column, condenser shall also be provided and shown in the plans.

Use of low flash point solvents, carcinogenic substances, benzene, xylene, toluene and other aromatic hydrocarbons and their nitro compounds/ halogenated derivatives, caustic, chrome process, nitro or amino process, pesticides and insecticides, phosphine, phosgene, crude oil, bleaching powder, aluminium powder, lead, mercury or arsenic compounds, heavy metals and all explosive or toxic materials should be done very carefully. Separate receivers should be provided for them. Solvent extraction plants using solvents like pentane, hexane, heptane etc., should be designed carefully. Sufficient means for fire protection including alarms should be provided. Special rooms for processes and workers should be constructed.

3 INDIAN STANDARDS AND NATIONAL BUILDING CODE

Various Indian Standards are available for considering safe design and layout of industrial buildings, plants and equipment. They are the good guidelines for all safety people. Some are mentioned below in Table 7.1 :

Table 7.1 : Indian Standards

No.	Title	I.S No.
1	Sectional List of Indian Standards on Safety	-
2	Sectional List of Indian Standards on Civil Engineering	-
3	Industrial plant layout	8091
4	Code of safe practice for layout of outside facilities in an industrial plant	8089

5	Safety requirements for floor and wall openings, railings and toe boards	4912
6	Structural safety of buildings : Masonry walls	1905
7	Structural safety of buildings : Loading standards	875
8	Structural safety of buildings : Shallow foundation	1904
9	Glossary of terms relating to doors	10428
10	Selection of , installation and maintenance of timber doors and windows	4913
11	Steel doors, windows and ventilators	1038
12	Steel windows for industrial buildings	1361
13	Industrial ventilation	3103
14	Industrial lighting	6665
15	Daylighting of factory buildings	6060
16	Steel Tubular scaffolding	4014
17	Fire safety of buildings (General) : Materials and details of construction	1642
18	Fire safety of buildings (General) : Electrical installations.	1646
19	Fire safety of industrial buildings : General storage and warehousing including cold storages.	3594
20	Installation and internal fire hydrants in multi-story buildings	3844
21	Safety code for handling and storage of building materials	7969
22	Fire resistance test of structures	3809
23	Code of practice for noise reduction in industrial buildings	3483
24	Industrial safety belts and harnesses	3521
25	Glossary of terms relating to corrosion of metals	3531
26	Recommended design practice for corrosion prevention of steel structures	9172
27	Code of practice for cathodic protection of steel structures	8062
28	Safety code for scaffolds and ladders	3696
29	Safety Code for construction, operation and maintenance of river valley projects.	10386
30	Standard colours for building and decorative finishes	1650

There are hundreds of such standards which may be selected from Title No. I & 2 above.

National Building Code

SP 7 - 1983 is a single code containing various IS on building construction in one volume. It contains regulations useful to various departments, municipal administrations and public bodies. It lays down provisions for public safety with regard to structural sufficiency, fire hazards and health aspects of buildings. Other subjects included are building requirements, materials, structural design, electrical installations, lighting, ventilation, air conditioning, lifts, acoustics, plumbing services, gas supply, safety of workers and public during construction and rules for erection of signs and outdoor display structures. It is also available in five groups as under :

Group 1 For architects
Group 2 For structural design engineers
Group 3 For construction engineers
Group 4 For building service engineers
Group 5 For plumbing services engineers

Following special publications are also relevant

SP 6 ISI Handbook for structural engineers (7 parts).
SP 10 Nomograms for thickness of masonry walls.

SP 16	Design aids for reinforced concrete,
SP 20	Handbook on masonry design and construction.
SP 21	Summaries of IS for building materials.
SP 22	Codes for earthquake engineering.
SP 23	Handbook on concrete mixes.
SP 24	Code for plain and reinforced concrete.
SP 25	Causes and prevention of cracks in building.
SP 27	Method of measurement of building works.
SP 33	Handbook on timber engineering.
SP 36	IS on soil engineering (2 Parts) for plumbing services engineers.
SP 41	Handbook on functional requirements of buildings.
SP 1650	Standard colours for building and decorative finishes. (Revision of IS:1650).

4 SITING CRITERIA

4.1 General Guidelines :

General Criteria for selection of location of industries are as under -

1. Land availability and its cost.
2. Raw material availability.
3. Labour availability.
4. Infrastructure availability.
5. Access to market.
6. Transport facilities.
7. Drinking and process water facilities.
8. Sewage and Drainage.
9. Place for solid and liquid waste disposal.
10. Interlinking with other plants.
11. Surrounding population density and distance from the public.
12. Distance from highway and railway and from transport centres.
13. Suitability of climate, environment and factors related to ecology, geology, meteorology, micro & macro biology.
14. Government policy advantages like subsidies, incentives and zoning (area reservation eg. SEZ) if prescribed.
15. Other techno-economic criteria.

Site of a nuclear plant poses potential hazard to surrounding public. Considering the magnitude and consequence of the worst scenario, its site should be selected.

Rules of zoning and town planning should consider above factors.

Some of these factors are explained below in brief.

Location: Plants producing or using highly explosive, inflammable or toxic substances in bulk should be located away from dense population. As per Section 41 A of the Factories Act, now, the Site Appraisal Committee shall examine the location of a hazardous factory.

From safety point of view increasing distance from the public reduces the effect of explosion, gas release and radiation on them. But real problem is increasing population in vicinity after establishment of a factory. Govt. should control them.

Climate: Study of prevailing winds is useful to decide location of offices and their air-conditioning air intakes, storage tanks, warehouses, drainage and waste disposal, direction of exhausted smoke, fumes, dust, gas etc., with respect to surrounding locality. Data of rain, flood, hurricane, temperature and other weather effects is also useful.

Terrain (land, topography) : If bridges over streams, ditches, etc., are necessary they should be fenced by handrails I m. high and intermediate rails. Natural structure like hills, mountains, sea or riverside, type of soil, mine, underground source etc. may be useful for special purposes.

Nature of Site : It should be large enough for safe layout with sufficient space for all buildings, roads, parking and storing areas, effluent treatment plant and future extensions. Minimum distances as per fire laws, explosive laws. and other laws must be considered. Scale relief models of the site in addition to maps are useful for pre-design and spotting potential safety problems. Soil testing should be carried out as per engineering advice.

Accessibility: Rail, road, river, sea and airport facilities should be ensured. Post and telegraph, telephone, fax. E-mail, internet etc. are useful for fast communications.

Environment: If air impurities and interaction of emissions .or sources of ignition etc. from adjacent sites are harmful, they should be considered. Noise and vibration due to neighbouring industries, transport vehicles, running trains, low flying aircraft should be considered.

Special environmental guidelines are given in Part 4.2 below.

General Provisions: Adequate water supply for drinking, process and fire fighting, drainage of rain water, process water, fire water etc., and water /air/ land pollution problems must be considered.

4.2 Environmental Guidelines :

Rule 5 of the Environment (Protection) Rules, 1986, gives following siting criteria to be considered by the Government while prohibiting or restricting the location of industries in different areas

1. Standards for quality of environment laid down for an area.
2. Maximum- allowable limits of pollutants (including noise) for an area.
3. Likely emission from the proposed industry.
4. Topographic and climatic features of an area.
5. Biological diversity of the area to be preserved.
6. Environmentally compatible land use.
7. Adverse environmental impact likely to be caused by the industry (EIA is required).
8. Proximity to a legally protected area.
9. Proximity to human settlements.
10. Any other relevant factor.

Procedure for prohibition or restriction is also given in above rule.

Site Appraisal Committee u/s 41A of the Factories Act, while considering any site application, may go through above criteria.

The Industrial Policy Statement of July 1980, recognised the need for preserving ecological balance and improving living conditions in the urban centres of the country. On the basis of this Policy,' indiscriminate expansion of the existing industries and setting up of new industrial undertakings within the' limits of metropolitan cities and the larger towns are restricted.

To prevent air, water and soil pollution arising out of industrial projects, the Industrial Licensing procedure requires that the entrepreneurs before setting up the industry should obtain clearance from Central/ State Air and Water Pollution Control Board. In respect of certain industrial development projects it is. not only necessary to install suitable pollution control equipment but also to identify appropriate sites for their location.

Following conditions are also to be fulfilled :

1. The State Director of Industries confirms that the site of the project has been approved from environmental angle by the competent State Authority.
2. The entrepreneur commits both to the State Government and Central Government that he will install the appropriate equipment, implement and the prescribed measures for the prevention and control of pollution.
3. The concerned State Pollution Control Board 'has certified that the proposal meets with the environmental requirements and that the equipment installed or proposed to be installed are 'adequate and appropriate to the requirement.

The entrepreneur will be required to submit half-yearly progress report on installation of pollution control devices to the respective State Pollution Control Boards.

Depending on the nature and location of the project, the entrepreneur will be required to submit comprehensive Environmental Impact Assessment Report, and Environmental Management Plans.

Refer the latest EIA notification from the MoEF.

Siting Guidelines:

In a selected site, the following factors must be recognised.

1. No forest land shall be converted into non-forest activity for the sustenance of the industry.
2. No prime agricultural land shall be converted into industrial site.
3. Within the acquired site the industry must locate itself at the lowest location to remain obscured from general sight.
4. Land acquired shall be sufficiently large to provide space for appropriate treatment of waste water still left for treatment after maximum possible reuse and recycle. Reclaimed (treated) wastewater shall be used to raise green belt and to create water body for aesthetics, recreation and if possible, for aquaculture. The green belt shall be ½ km wide around the battery limit of the industry. For industry having odour problem it shall be a. kilometre wide.
5. The green belt between two adjoining large scale industries shall be one kilometre. Green belt should also be provided within factory premises.
6. Enough space should be provided for storage of solid wastes so that these could be available for possible reuse.
7. Layout and form of the industry, that may come up in the area must conform to the landscape of the area without affecting the scenic features of that place.
8. Associated township of the industry must be , created at a space having physiographic barrier between the industry and the township.
9. Each industry is required to maintain three ambient air quality measuring stations within 120 degree angle between stations.

4.3 Meteorological aspects :

While selecting a site, climatic conditions should also be considered. It should not have any adverse effect on industrial processes otherwise more control measures may be required. High or law temperature, more moisture, high or low wind velocity, frequent raining, cloudy atmosphere, Infrequent changes in weather condition, effect of nearby seashore, effect of hills and jungles, effect of long time sunrays etc. have considerable effect on raw materials, products and processes. Gas leakages from industry, their concentration and damage distances vary depending on weather conditions.

Global warming and green house effect should be decreased by preventing emissions of CO_2, and O_3, depliting substances.

MoEF guidelines provide further information.

4.4 Seperation Distances :

Separation distances (safety distances to be maintained) suggested by the Government guidelines are as under :

In siting industries, care should be taken to minimise the adverse impact of the industries on the immediate neighbourhood as well as distant places.

Some of the natural life sustaining systems and some specific land uses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protecting such industrial sites, the following distances from the areas shall be maintained:

1. Ecologically and/or otherwise sensitive areas: at least 25 km; depending on the geo-climatic conditions the requisite distance shall have to be increased by the appropriate agency.
2. Coastal Areas: at least Vi km from high tide line.
3. Flood Plane of the Riverine Systems: at least ½ km from the flood plane or modified flood plane affected by dam in the upstream or by flood control systems.
4. Transport/Communication System: at least ½ km from highway and railway.
5. Major Settlements (3,00,000 population) : distance from settlements is difficult to maintain because of urban sprawl. At the time of siting of an industry if any major settlements notified limit is within 50 km, the spatial direction of growth of the settlement for at least a decade must be assessed and the industry shall be sited at least 25 km from the projected growth boundary of the settlement.

Separation distances are either between two units or a single unit and a source of ignition. It is normally between the adjacent edges of the units and not from centre to centre.

Factors to determine separation are (1) Explosion effect (2) 'Radiant .heat from a burning material (3) Ignition of a vapour escape and (4) Heavy concentration of a toxic gas.

Normally 15m (50 ft) is suggested for the storage of petroleum products excluding LPG. For LPG a smaller distance is allowable if radiation walls and/ or water drench systems are provided. From an ignition source, for ethylene storage, 90 m is suggested for pressure storage and 60 m for refrigerated storage. Risk of failure of a pressure storage is higher than that of refrigerated storage.

Mecklenburgh (1973) suggested 15 m distance from process units, furnaces, boilers, effluent plants and loading areas and 30 m from cooling towers, gasholders and flare stacks to adjacent process units, main roads or site boundary.

Some suggested distances are as under:

No.	Unit	Separation Distance (mt)
1	Flammable liquid, low to medium pressures	10-25
2	High flammability, high pressure	35-50
3	Direct fired boilers and furnaces	35-50
4	Blow down stack with flare	40-75
5	Loading facility	35
6	Public roads and railroads	35
7	Cooling towers	35
8	Storage tanks	25-50

ILO guidelines (see reference No.7) suggest following table of approximate separation distances for **Major Accidents Hazard works:**

Table 7.2 : Separation Distances for MHA units :

Chemical	Largest tank size (tonne)	Separation distance (mt)
LPG at >1.4 bar absolute OR Flammable gas or moisture at > Boiling Point	25-40 41-80 81-120 121-300 >300 25 or more cylinders or tank up to 5t	300 400 500 600 1000 100
LPG, refrigerated, at ? 1.4 bar absolute	50 or more	1000
Flammable gas or mixture	15 or more	500
Flammable gas or Mixture having BP<0^{o}C, refrigerated or cooled at ? 1.4 bar absolute.	50 or more	1000
Liquid or mixture of liquids having Flash Point < 21^{o}C	10000 or more	250
HF SO2 SO3 Acrylonitrile HCN CS2 Chlorine Bromine H2 Phosgene Methyl isocynate EO, or Propylene oxide (ambient pressure) Liquid O2 Ammonium nitrate – bagged in stacks of	10 or more 20 or more 15 or more 20 or more 20 or more 20 or more 10-100 > 100 40 or more 2 or more 2 or more 1 5-25 > 25 500 or more 300 t	1000 1000 1000 250 1000 250 1000 1500 600 500 1000 1000 500 1000 500 600

$$600\left[\frac{\text{stack size (t)}}{300}\right]^{\frac{1}{3}}$$

- Loose distance =		

In above separation distances no restriction category B development, category C restricted and within about 2/3 of the distance, category A is restricted. Categories are as under:

Cat A - Residential houses, hotels, flats.
Cat B - Industrial, factories, warehouses.
Cat C - Special, schools, hospitals, old peoples' homes.

These distances are tentative and may be slightly modified under local circumstances. If they are found unacceptably large, quantified risk assessment (QRA) should be carried out to assess distance.

Instead of using such fixed distance criteria, another approach is to calculate the hazard range by using formulae for gas dispersion or fire/explosion effect.

See Table 2 & 3 for safety distances under the Petroleum Rules 2002 for petroleum tanks.

Because of the shortage of space, it may not be possible to maintain an ideal separation and in that case, the decision should be made with safety considerations.

Diversion walls can be used to divert vapour flows to a safe area. Firewalls can be used: to protect from radiant heat and explosion (blast) wall to protect from the impact of explosion. Steam curtains or drenches are used to provide separation from fire or ignition. ..

5 NEED FOR PLANNING AND FOLLOW UP

5.1 Need and Approach:

Need of planning for safety and health and 'safety engineering approach in design, planning and construction of new plant or new alteration or addition' are basic and most essential, because:

1. General efficiency and safety in industrial activities can be greatly increased thereby.
2. Accidents and occupational diseases can be prevented from the earliest days.
3. Cost saving factors can be considered by effective use of floor area, providing ample space for men, materials and machines, reducing the cost of material handling, reducing the time of work or process and making efficient use of resources, personnel and equipment etc.
4. Efficient flow of work is maintained, and
5. Safety and comfort of people are achieved by considering ergonomic aspects.

Therefore safety and layout engineer must take into account :

1. Products and product layout
2. Raw materials, processes and their layout
3. Size and type of site and building.
4. Machinery, vessels and equipment required.
5. Assessment of manpower required.
6. Relationship between departments.

7. Process flow chart.
8. String and flow diagrams.
9. Templates and scale models.
10. Drawings and plot plans, and
11. Travel chart etc.

5.2 Follow up :

As need for planning is important, follow up action according to that planning is equally important. Without follow up no planning can be executed. Therefore distinct responsibilities should be assigned to different persons to implement the follow up actions of every stage or step decided in planning. It should be reported to the higher officer, feed back should be received for correction or addition if any and the work should be completed within a stipulated time. All points of safety, health, environment and ergonomic factors should be included from the built-in stage. If this follow-up is missed in the initial stage, later follow-up may become continuous and costly.

6 PLANT DESIGN AND LAYOUT

6.1 Components in Design Process:

If components of any structure, vessel, equipment etc. are weak or not properly designed, they may fail. Therefore a component should-be designed to withstand (1) static loads (2) dynamic loads (3) internal and external pressure (4) corrosion & erosion 11(5) loads due to large differences in temperature / pressure and (6) loads due to external impacts (wind, settlement, earthquakes etc.).

Selection of proper "factor of safety' and proper material of construction (MOC) are important form design point of view.

These loads may be included in the design process. It is of more importance for pressure plant containing flammable, explosive or toxic substances or liquids above their flash points or boiling points.

Components of control systems (manual or automatic) should be properly integrated with necessary safety devices, trips and alarms, interlocks, pressure reducing valve (PRV), non-return valve (NRV), excess flow valve (EFV) and automatic process controllers etc.

Reliability of components of main and sub-systems (parts) is important. See Part 5 of Chapter-19 for reliability aspect.

Load and pressure testing of components i.e. testing of the assembled systems, piping and joints, valves and fittings is also necessary.

6.2 Travel Chart:

Travel chart is a simple and useful, method to analyses deficiencies in the layout of a factory and in planning a good layout.

The deficiencies in a poor layout are :

1. Congestion on the shop floor.
2. Excessive waiting time of machines and materials.
3. Poor space utilization.
4. Absence of easy access to machines, tools and materials.

5. Excessive handling of materials.
6. Irregular flow of process and materials.
7. Back tracking and zigzag movements.
8. Absence of necessary aisles and routes.
9. Unbalanced activities resulting in poor utilization of men, machines and materials, and
10. Inflexibility of layout allowing no scope for expansion or alteration needed with time.

The travel chart technique detects above deficiencies to improve the plant layout and suggests follow-up action necessary. It is a mathematical approach which measures quantitatively the movements of materials and in-process work. The purposes of such measure are:

1. To assess the quantities and the nature of materials flowing from area to area and from machine to machine.
2. To reduce movements to minimum. .
3. To relocate contributing and user areas on the basis of percentage contribution, and
4. To arrange operations in each section for self sufficiency.

Unit movement is noted by multiplying distance and frequency. From the data of number of components, their weights, distances travelled, frequency of trips etc., templates for the machines and equipment and other details, the travel charts are prepared.

The .study of travel chart suggests improvements in materials handling methods and machines in operation, types of containers, aisles, travel routes etc.

6.3 Planning, Design and Layout :

Plant or factory premises vary in size and manpower employment. There are giant petrochemical and fertiliser plants on one end and small factory in a single room on the other end. Under the Factories Act, more welfare facilities are required from bigger factories depending on number of workers arid male-female employment. Stringent safety provisions are applicable to chemical plants and major hazard (MAH) installations. Before starting a factory permission from local authority and other related government departments is also required. Where pollution is possible, permission from State/Central Environment Department and Pollution Control Board is also necessary.

Definition of a 'factory' is given under the Factories Act 1948 and it is the main Act (together with State Factories Rules) applicable to the layout, design, construction and working of a factory.

A plant should be located after considering siting criteria mentioned in Part-4, and be constructed by considering statutory requirements mentioned in Part-2.

6.3.1 General Principals of Planning and Design

They are as under :

1. Siting criteria as mentioned in Part 4.
2. Good transportation facilities.
3. Safe handling and storage facilities.
4. Personal and Welfare facilities.
5. Engineering, utility and safety facilities.
6. Walkway, stairs, .platform, ramps etc.
7. Good lighting and ventilation.
8. Elevators and lifting machines.

9. Boilers and pressure vessels.
10. Fixed and portable machinery and equipment.
11. Electrical installation.
12. Fire protection.
13. Other provisions for health and safety, viz. effluent disposal, water, firs-aid, emergency power, equipment and emergency planning etc.

General principles of any workplace design:

They are as under

1. Plan the ideal, then the practical.
2. Plan the whole, then the detail.
3. Plan the work process and equipment around the system requirements.
4. Plan the workplace layout around the process and equipment.
5. Plan the final enclosure around the workplace layout
6. Use trials to evaluate alternatives and to check the final design.

Design aspects should include proper buildings and roads layout, storage & process layouts, proper heights, lights, depths, spacing and dimensions considering ergonomic requirements, loads and climatic factors and specific process hazards.

Some notable points for good planning and design are:

Sound foundations, stable construction and loading, non-congested machinery layout (safety distance 1 m), no overcrowding (otherwise claustrophobia is possible), minimum floor area per worker (1 to 2 m^2), minimum alley width, safe roadways, walkways, yards etc., prescribed ventilation area (15% of floor area), sufficient natural and mechanical ventilation, humidity control, sufficient natural and artificial lighting, open plant for chemical processes, dykes, boundaries and blast walls (to' withstand 7 kgf/cm^2 force), safe layout and erection of chemical vessels and equipment, ergonomic considerations, segregation of noisy and dusty processes, fencing and covering of water-ways, reservoirs, ditches, floor openings, gutters etc., separate entrance and exit gates, parking plots, safe layout of control room, provision of fire prevention and protection systems, safe storage of flammable, explosive and toxic materials, waste disposal T arrangements for solid, liquid and gaseous wastes, ; effluent treatment plant (ETP), scrubbers, incinerators, flare or exhaust as per requirement, safe : discharge of smoke, fumes, dusts, gases etc., ' maintenance of separation distances mentioned in Part-4.4, proper layout of utilities (water, power, steam, air, oil, inert gas etc.) and ancillary services, : safe transportation and security arrangement, hazards identification and removal, safe pipe work, follow-up of standards, codes and reliability criteria, \ limitation of inventory, fail-safe design, built-in safety devices etc.

Thus points of plant layout and design are numerous and selection of particular point depends on process, technical and safety requirements.

6.3.2 General Principals of Plant Layout

General Layout: Size, shape, location, construction, buildings layout and other facilities should permit efficient utilization of machines, processes and materials. Need and possibility of one storey or multi-storey structure should be decided.

Layout should be properly planned to allow smooth flow and efficient use of men, materials, methods, processes, time cycle etc. and should allow good and .safe working conditions to prevent any accident or risk.

Some General Principles for good Layout arc:

1. Enough work space (2 m2 per 'person) should be provided for workers to work without restriction.
2. Proper roads, walkways, tracks, alleys, catwalks etc. should be provided for free passage of men and materials to avoid delay and obstruction.
3. Sufficient doors, windows, ventilators and open space must be provided for good ventilation and lighting.
4. Installation of machinery, floors, stairs, lifting machines, electric wiring etc. must be done to ensure safety. Allow at least I m space around each machine.
5. Keep the handling of materials to the minimum. Use mechanical means to reduce manual strain.
6. Provide safe means of access to all work places.
7. Provide safe transport facilities for men and materials.
8. Provide adequate emergency exits.
9. Purchase and arrange in orderly manner machines and equipment with built-in safety.
10. Isolate high noise, vibration, fire, explosion and toxic hazards. Design a work bench, table, booth, roof, ladder, platform, sheet, support etc. with safety standards to avoid such hazards.
11. Allow space for future expansion.
12. Provide repair and maintenance workshop, welfare facilities and education and training facilities.
13. Use appropriate colours, notices, signs, labels, posters etc. for safety.
14. Provide easy locations of fire alarms, fire fighting equipment, personal protective equipment, emergency assembly points, medical centre, safety office etc.
15. Provide and maintain good housekeeping.

Other factors of plant layout and design from safety point of view are:

1. Safe design and construction using safety standards and good engineering practices.
2. Statutory requirements for plant layout and design.
3. Containment of leakage and accidents.
4. Segregation of different risks.
5. Safe storage, process, utilities and waste disposal design.
6. Safe control room location & design.
7. Emergency control devices.
8. Fire fighting and gas leak control facilities. Ample water storage.
9. Auto controls, alarms, trips, interlocks and necessary safety devices.
10. Railings and guarding at chances of fall, cross over and on moving machinery.
11. Roads of sufficient width and signs.
12. Safe loading, unloading, transport and piping facilities.
13. Security round the clock.
14. Wind direction and speed indicator with recorder to know wind direction and speed.
15. First aid centre and ambulance van.

The site layout is prepared first, then the plot and equipment layouts. Site is subdivided into blocks or plots. Equipment layout includes P & I diagrams and fire equipment layout. This is as under –

Plant layout

- Site layout
  - Preliminary layout
  - Main layout
  - Segregation
  - Separation distances
  - Fire containment
  - Services/ Utilities
  - Effluents
  - Transport of materials
  - Emergencies
  - Security
- Plot layout
  - General considerations
  - Hazards
  - Fire fighting
  - Escape
  - Construction
  - Operation
  - Maintenance
- Equipment layout
  - General considerations
  - materials
  - P.&I. diagram
  - Fire equipment layout

6.4 Factory Building and Internal Layout

IS:875, 1904 and 1905 for structural safety and IS:8089 and IS:8091 for layout safety are important.

For approval of drawings under the Factories Act and Rules see foregoing Part 2.

Location of Buildings : Segregation of raw material storage, process building, finished product storage and storage of hazardous materials, flame or ignition sources is necessary. Statutory specifications for storing flammable liquids shall be followed. Fire resistant wall is required between flameproof and non flame proof area. A detailed flow sheet shall be used for layout. The cross flow of materials and/or pedestrians should be minimised.

All buildings and parking plots should be located near periphery to limit internal traffic. The entire parking area should be fenced. White lines 10 to 15 cm wide, standard stalls of 5 m x 6 m, driveway of 8 m, for two-way traffic and unobstructed viewing are desirable. Separate entrances for incoming and outgoing vehicles and night light of about 100 lux m^2 at a height of 1m should be provided. Buildings having more people should be away from hazardous areas. Production building should have roads and access for fire fighting, maintenance, vehicles, lifting machines etc. The flow of materials should be such that its length of travel and frequency of handling are minimised. Cooling towers should be so located to minimise mist and ice hazards.

Ventilating, heating and air-conditioning are needed for personal comfort and sometimes for process conditions. Extra ventilation should be provided where heat or bad fumes are generated. Boilers, fans and air-conditioning equipment should be located in separate rooms for their fine adjustment and confinement of noise. Boilers should receive adequate air and combustion by-products should be exhausted safely. Location of incinerator should ensure that negative pressure differential in a building does not cause an incinerator stack to serve as an air source.

Space for storing supplies, tools, frequently used equipment, racks, bins, shelves etc: should be provided. Waste storage and additional required facilities should also be considered.

Rail, Road and Footpaths: Good design for railway sidings is necessary. Provisions for piping, valves, pumps, derails etc. to unload or load tank Wagons, guarding of side track and public thorough fares and clearance (distance) from main plant are necessary.

Roads should be carefully laid out, substantially constructed, well surfaced, drained and kept in good condition. Road should be at least 11 m. away from buildings. Heavy duty truck hauling requires road up to 16 m. wide for two-way traffic with ample radii curves. Gradient up to 8% and slight crown for drainage with ditches to carry off water are necessary. Traffic signs, markings, speed breakers should be provided. Good footpaths with shortest distance should be .provided to discourage short cutting Concrete is preferred for footpaths.

Floors, Platforms and Catwalks: The floor area should be sufficient to allow men, machines and materials without any obstruction and overcrowding. As per Section 16 of the Factories Act, 14.2 m^3 breathing space per worker limited to a height of 4.2 m is necessary. The minimum floor area per worker in power and non-power factories should be 3.3 sq. m. (36 sq. ft.) and 2.3 sq. m. (25 sq. ft.) respectively. Minimum roof height should be as mentioned in Part 2.1(A). The floor should be non-skid type of sound construction, easily cleanable, free from moisture retention and well maintained. Other factors of floor viz. load bearing (strength), durability, noise, drainage, resilience, appearance, light reflection, dustiness, chemical composition and reaction, heat and electrical conductivity and maintenance should be considered for proper selection. Marble, slate, asphalt, tile, linoleum, cement and wood are reasonably safe, provided their surfaces are properly maintained. Welding floor should be of noncombustible material. Spark-proof and conductive flooring such as magnesium and conductive rubber are good where flammable air mixture is likely to be ignited by a friction or static charge.

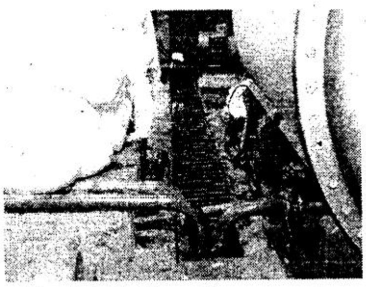


Fig. 7.1 Grill on floor opening

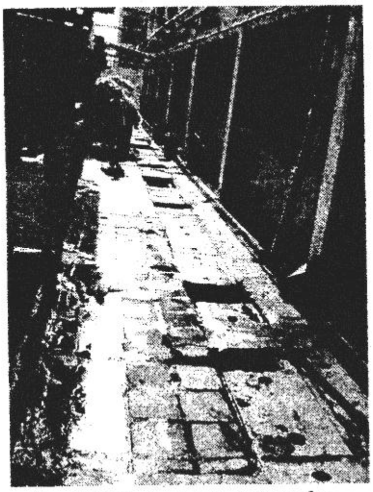


Fig. 7.2 Gutter not properly coverd

Floor openings and floor holes, wall opening and wall holes, open-side floors, platforms and catwalks shall be guarded with railings and guards as mentioned in IS:4912. General height of railing is 100 cm maximum and 75 cm minimum with minimum distance between its members (posts) as 20 cm and capable of withstanding a point load of at least 90 kg in any one direction. Floor covers should withstand a truck load of 9 to 15 tonnes.

The gangway should be at least 1 m wide and firm to withstand movement of a trolley, hand truck. Catwalk is a passage way for persons elevated above the ground or any floor level such as foot walk along shafting or a walkway between buildings. Every catwalk should be al least 42 cm wide and guarded by a **tow guard** (a vertical barrier erected along exposed edges of a floor opening, platform, -catwalk, ramp etc., to prevent falls) of 15 cm nominal height. Ramps slope should not be more than 15°.

Fig. 7.3 Catwalk, tow guard and railing

Stairs, ladders and Scaffolds: Stairs are safer than ladders. Circular stairways should be avoided. Stairway slope should be 30° to 35° from the horizontal. The maximum height of a staircase should be 3.7 m (12') with riser height between 13 cm to 20 cm and tread width 23 cm (9") or more. The width

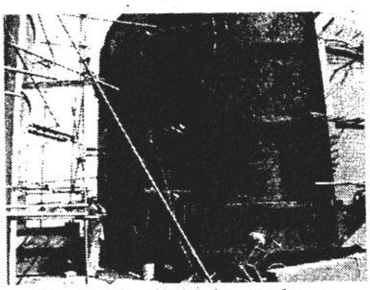


Fig. 7.4 Scaffold for tank

of the staircase should be 1.12 m (44") or more and load bearing i strength of 500 kg./sq. I m. (100 lb./sq. ft.). Two \ distant staircases are j needed at hazardous

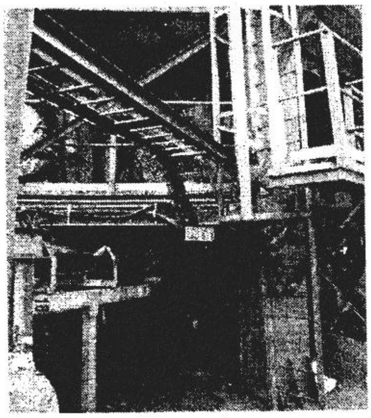


Fig. 7.5 Ladder and Monkey ledder

Scaffold and its supporting members should be designed to support a given load with a factor of safety at least 4 No plank less than 5 x 25 cm should be used for scaffold plains. Their overlap distance should be at least 30 cm. Tubular steel scaffolds designed, tested and built by experts are more preferable over built-on-the job wood scaffolds. Their advantages are: safety of worker, lower cost, lowered fire hazard and good appearance. 15:2750, 3696 and 4014 are on scaffolding.

Exit, Doors and Windows: Maximum distance between two exits should be 20m in high hazard factories and 30 to 50m in low hazard factory. They should be as per requirement. Exit doors should be clearly visible and open outwards. The standard size for a door and window are 200 x 120 cm and 150 x 90 cm respectively. A sill level of a window from working floor is 1 m. For every 9.35 sq. m. (100 sq. ft.) wall area one window of standard size should be provided. Normal distance between two windows (centre to centre) should not exceed 2.4 m. (8'). The window shutters should also open outwards. Ventilators should be provided SOT a height above 3.5 m.

Stores: Mechanical handling should be preferred. All bunds or dykes should have good drainage. Local stores and stocks should not cause obstruction. Inventory and site of hazardous materials should be limited. Stocks, racks, shelves, stacks, electrical machinery etc. should be protected from rain or water.

Loading-unloading should be so located to minimise disturbance to traffic. Storage of explosive, reactive, unstable, flammable and toxic materials should be so designed to maintain sufficient distances within the storage area and between other areas. Maximum limit per unit area should be decided so that if larger quantities are to be stored, new store area well separated from the first may be provided.

Safe storage of flammable, explosive, toxic and radioactive materials should be ensured. Flameproof electric fitting, fuming (low Boiling Point) chemical in AC room, closed (pipe) transfer, safe pumping, local exhaust etc. are necessary.

See also foregoing Part 2 and Rule 66(1), GFR, for storage safety of material.

See Chapter-16 for working at different levels.

Engineering workshop: Clear gangways around dangerous machines, separate welding bays with shielding, ventilation and fume extraction, outside racks and chains for gas cylinders, permanent lifting gear at correct place for all foreseeable loads, machine to machine or machine to wall distance of at least 1 m., clothing and tool cupboards, and first-aid box etc., need good planning.

Layout of equipment: Various methods are used to determine the safest and efficient layout of production machines and equipment. Threedimensional models made to scale can be rearranged on a scaled floor plan to determine such layout. Congested area should be anticipated and avoided. A vertical distance of at least 2.2 m is generally specified between passage stairways and overhead structures to provide ample clearance (head room). Overhead cranes and conveyors require at least 60 cm of vertical and horizontal clearance. Aisles for two-way traffic should be more than I m wider than twice the width of the widest vehicle. For heavy traffic, aisles from 4 to 6 m wide are specified. Aisles should have a 2 m radius for truck turn and should have no blind corners. Where ramps are needed, a I m wide walk-way should be provided.

All hot parts should be lagged to avoid burns. Operations of ignition sources (welding-cutting etc.) should be located away from use or store of flammable materials. Toxic operations should be kept away from a populated area.

Electrical Equipment: Complete metal enclosed unit substations should be installed and grounded. Oil-filled transformers may give off flammable gases which should be safely discharged. Non-flammable transformers are desirable near flammable area. Short circuit protective devices should be large enough to carry the maximum short circuit current. Circuit breakers, fuses and safety switches should not fail. Grounding system should be capable of conducting earth leakage current. Battery room should be isolated and well ventilated. Automatic -CO injection system helps to extinguish electrical fire. There should be sufficient sections to allow maintenance without shutting down the whole system. Metal enclosures should be grounded. Cable circuits should be enclosed in rigid conduit or interlocked armour cable. Metal enclosed plug-in-bus-ways are desirable for machine tools. Three wire systems with one ground wire for all electric equipment are necessary. Electric shock guards (ELCB) are also desired.

Others: Laboratories with fume cupboards and selected flooring, offices with proper layout, safe rack, shelves, height and designed furniture, canteen, lunchroom, rest room, cloak room, creche, ambulance room etc., should be as per statutory requirements. ETP and waste disposal plant should be provided from beginning.

All gutters, reservoirs, waterways, ditches in or near the factory should be fenced to prevent fall.

Underground rooms should have sufficient lighting, ventilation and proper height (> 3 m). Fumes generating process is not allowed therein.

For good housekeeping, lighting & colour, ventilation & heat control, electrical safety, noise & vibration, fire & explosion, machine guarding, material handling and working at different levels see Chapter-3 to 16 respectively.

6.5 Standards and Codes of Practice for Plant and Equipment:

See foregoing Part-3 and Table 7.1 for Indian Standards for plant construction.

While referring to standards and codes, it is useful to understand following definitions:

1. A criterion is any rule or set of rules that might be used for control, guidance or judgement.
2. A standard is a set of criteria, requirements of principles.
3. A code is collection of laws, standards or criteria relating to a particular subject, such as the National Building Code, National Electric Code, National Fire Code etc.
4. A regulation is a set of orders or rules issued to control the conduct of persons or manufacture within the jurisdiction of the regulatory authority e.g. Indian Boiler Regulation (IBR).
5. A specification is a detailed description of requirements, usually technical.
6. A practice is a series of recommended methods, rules or designs, generally on a single subject. Design handbooks, guides or manuals contain non-mandatory practices, general concepts and examples to assist a designer or operator.

Standards are based on necessary tests and requirements. They give assurance about soundness, quality, durability, reliability, safety etc. Design standard.s give sound criteria for safe design. Quality standards indicate proper material or product. Codes and Standards for pressure vessel design provide correct method of construction and testing. Standards may be mandatory or voluntary. Test standards are set and, used for testing and certification of products. Indian Standards on safety are available on thousands of Hems.

Codes of practice are generally followed where no statutory provisions are available or where missing details are required. On hundreds of 'items of manufacturing there may not be any legal standard. In that case code of practice should be followed.

In designing foundation work for any building, in designing and construction of steel structure, vessels, piping, supports, equipment etc., safety standards and codes should be followed. BIS (Bureau of Indian Standards) Handbook - 1996, gives 14357 standards of which some examples are given in Part-3, Table 7.1. Many 'Safety Code for ....' are given in alphabetic index of this handbook. Some examples are given below in Table 7.3.

Table 7.3 : Code of Practice & Safety Codes (IS)

Code of Practice for…	**IS**
Architectural and building drawings.	962
Day lighting of buildings	2440
Demolition of buildings	4130
Design & construction of floors & roofs	14215
Design & construction of steel chimney	6533
External hydrant system	13039
Fire safety in hotels	13716
Fire safety in iron & steel industry	13694
Galleries and opening in dams	12966
Laying mastic flooring in LPG industries	13074
Manufacture of safety books & shoes	13295
Measurement of civil engineering works	3385
Structural safety	13063
Super capacity bucket elevator	12941
Safety Code for….	**IS**
Body Protection	8519
Chemical Laboratory	4209
Colours and signs	9457
Concrete framed structures	8989
Conveyors	7155
Electro heat installation	519
Footwear for steel plants	10348
Industrial radiography	2598
Working with construction machinery	7293
Handling and storage of building materials	7969
Hot bituminous construction	5916
Layout of industrial plant	8089, 8091
Plant railways	8218
Powered industrial trucks	6305
Conditions for woodworking machines	8964
Data processing equipment	10422
Devices for gas cylinder	5903
Equipment, eye, face, ear	8520, 8940
Foot & Leg	10667
Glove, industrial	6994
Masonry walls	1905

Nets, industrial	11057
Structural loading	875
Hand tools	8235
Scaffolding, steel	4014
Relief valves	3233
Shallow foundations	1904

For ISO 14001 and OHSAS 18001 See Part 1.17 of Chapter 19.

7 ERGONOMIC CONSIDERATION FOR PLANT DESIGN AND LAYOUT :

Important ergonomic factors to be considered in plant layout and design include :

1. Free space (80 to 100 cm) around each machine for easy and safe movement.
2. No overcrowding. Breathing space of 14.2 m" per worker (max height 4.2 m).
3. Ventilation opening -15% of the floor area minimum. Window bottom height I meter or less from the working floor for natural ventilation.
4. A traversing part or materials carried by machinery should not approach within 50 cm (Sec. 25 of the Factories Act prescribes 45 cm) of any fixed structure which is not part of the
5. Suitable platforms, safe means of access and lifting appliance suspension points should be provided to facilitate cleaning and maintenance
6. Height and position of seats, valves, gauges, indicators, displays, meters, knobs, controls, handles, switches, push buttons, brakes, notices etc. should be suitable to the operators. Safe manual lifting' methods should be utilised.

Types of ergonomic design are as under:

No.	Type	Includes
1.	Work-space design	Seat, bench or console (control or comfort) design, positions of controls, displays & materials, operator's body, data and their working models including computer graphics.
2.	Environmental design	Light, ventilation, heat, humidity, noise, vibration etc. comfortable to the operator.
3.	Work time or situation design	Working hours, intervals, shift schedule and inter-personal aspects of work.
4.	Interface design	Exchange of information between man and machine or environment e.g. display gives and control receives information. Proper design of such displays (pointers, letters, numbers, figure etc.) and controls (knobs, brakes, switches, size, shape, position, forces etc.) most convenient to the men.
5.	System design	Allocation of function / job between man and machine and procedure. New techniques to understand limitations of each other and to fill the gap by the best design.

All these areas overlap and are interrelated. The main object of such ergonomic design is to get long term gain with no adverse effects on health and safety and to minimise human errors, efforts, stress and strain and ultimately risks and accidents.

Workplace design calls for following ergonomic factors :

1. Standing position offers more mobility, more arm strength application, less front-to-rear room, no seat and greater latitude in workstation design.

2. Sitting position offers forceful pedal operation, less fatigue-, precise vision.

3. Work object or job position should, be close to the front edge of the work surface to avoid more bending or leaning.

4. Sufficient room for hands and feet movement with footrest and backrest to work while sitting.

5. Visual displays should be in front of the body and below eye level so that the line of sight is declined 10 to 40 degree below the horizontal level.

6. Avoid holding time of work piece or hand tool to minimise muscle tension.

7. Use lever mechanism to apply less force. Take advantage of mechanical design, appliance, equipment, instrument etc to reduce manual work. '

8. Foot controls for seated operator, soft floor (e.g. rubber mat) for standing operator, adjustable chairs to maintain proper siting height, permitting posture change to avoid fatigue, allowing sitting/standing alteration and enough space for working are all to be considered in ergonomic design.

9. Computer operators have posture and vision complaints, e.g. musculoskeletal pain & discomfort, eye strain and fatigue. Studying the position, furniture, equipment, lighting etc. should be redesigned. Upright trunk and neck position, forward-declining set surface, properly shaped backrest and properly placed controls and displays are necessary.

See Part 13.4.4 of Chapter 5 and Part 3 of Chapter 24 for more detail.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. . Important points to be considered at drawing stage of a factory building.
2. Various dimensions regarding roof height, sanitary blocks, ventilation, ambulance room, canteen etc. under the Gujarat Factories Rules, 1963.
3. Dangerous operations vis-a-vis design of a factory building.
4. General guidelines (criteria) for siting of an industrial plant.
5. What are separation distances? Give the examples.
6. Factors to be considered for good planning and design of a factory.
7. General considerations for lay out and planning of a workplace/work station.
8. Safety factors for plant layout. OR Factors for process design.
9. Design aspects of floors, platforms and catwalks OR those of rail, road and footpaths. 10.
10. Ergonomic factors for layout and design of a factory building.
11. Difference between standard, code, regulation, specification and practice.
12. Advantages of good plant layout and machinery with reference to safety.

2. Write Short Notes on.

1. Indian heritage of building and construction.
2. Old Bhartiya' schools or branches of Engineering.
3. Statutory provisions for lighting ventilation, temperature and exhaust for a factory building.

4. National Building Code.
5. Siting criteria for deciding location of a factory.
6. Government guidelines for siting an industry.
7. Points to be considered by safety and layout engineer for layout of a factory.
8. Travel chart.
9. Items of good planning OR General principles for workplace design.
10. Location of electrical equipment in a factory
11. Improving safety and productivity through workplace design.
12. Factors of ergonomic design of a plant.
13. Benefits of standardization.
14. Types of plant layout.
15. Meteorological aspects.

3. Comment on following whether it is true or not and why?

1. Ancient Bharat was much advanced in architecture.
2. Environmental guidelines (e.g. rule 5 of E(P) Rules) are not useful to decide location of a hazardous factory.
3. Planning of a factory is dependent on size of land only, no other factors are important.
4. Safety and productivity cannot be improved by layout or design of a plant.
5. Environmental factors should be considered while planning for a factory.

Reference and Recommended Readings

1. References mentioned in Part-1 of this Chapter for Indian heritage.
2. The Factories Act 1948 and the Gujarat Factories Rules 1963.
3. Various Indian Standards mentioned in Part-3 and elsewhere in this Chapter.
4. Accident Prevention Manual for Industrial ' Operations, National Safety Council, Chicago, USA.
5. Industrial Hazard and Safety Handbook, King and Magid, Butterworths.
6. Process Equipment Design, M.V. Joshi, Macmillan India Ltd., Delhi.
7. Major Hazard Control, A practical manual, ILO, Geneva.
8. Loss Prevention in the Process Industries, Frank P Lees, Butterworths.
9. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
10. Site Safety by JC Landey.
11. Building Security : Handbook for Architectural Planning and Design by Barbara A Nadel
12. Construction Safety Auditing Made Easy : A Checklist Approach to OSHA Compliance, Second Edition by Kathleen Hess-Kosa
13. Construction Safety Handbook : A Practical Guide to OSHA Compliance and lnjuryPrevention by Mark McGuire Moran.
14. Construction Safety Management and Engineering by Darryl C. Hill, Editor.
15. Elevated Work Platforms and Scaffolding : Job Site Safety Manual by Matthew J. Burkhart, Michael McCann and Danial M. Paine.
16. Facility Manager's Guide to Security : Protecting Your Assets by Robert N. Reid.
17. Handbook of OSHA Construction Safety and Health by Charles D. Reese and James Vernon Eidson.
18. Office Building Safety and Health by Charles D. Reese
19. Office Ergonomics Safety Guide by Canadian Centre for Occupational Health and Safety.
20. Safety- Through Design by National Safety Council, USA.
21. Manual of Construction Safety by ILO, Geneva
22. Security Planning and Design : A Guide for Architects and Building Design Professionals by the American Institute of Architects, Joseph A. Demkin. Editor.

CHAPTER – 8

Good Housekeeping

THEME

1 MEANING OF HOUSEKEEPING:

Industrial housekeeping is generally classified as good or bad (poor) housekeeping. For the purpose of evaluation, ranking or marking, it is further classified as excellent, good, average, below average and poor or bad housekeeping.

The concept of good housekeeping is emerged from the results of bad housekeeping, which is the direct cause of many accidents. Poorly maintained plants and equipment, improperly stored materials, .tools and tackles, irregular or inadequate plant inspection,, unsafe environment and persons not conscious of all these are a potential cause of many accidents. Accident statistics explained in Chapter-5 and also in subsequent Part 4.1 reveals this fact In Part 12 of Chapter-5, in conclusion of the statistical tables, Some causes are highlighted to pay more attention. Majority of these causes viz. Stepping over or striking against objects, handling goods or articles, use of hand tools, falling on floor or in pit etc., hot or corrosive substances are because of poor or bad housekeeping. These causes of accidents 'can be removed by good housekeeping. This indicates the basic need of good housekeeping.

The term Good Housekeeping is sometimes loosely understood as simple floor cleaning or broom stick operation. But it is not so. It has a wider Cleaning including up-keeping of all industrial activities in orderly manner to minimise the accidents due to improper planning, placement, arrangement, .handling etc., everywhere in the industrial premises. In short it can be explained as a place for everything and everything in its proper place. It pays attention on removing all unsafe conditions in the plant and thereby increasing safety and productivity.

Housekeeping is not just a need-based cleaning. It is more than that. In addition to regular daily cleanliness, it includes orderly arrangement of tools, equipment, materials and process flow. It is an integral part of industrial activity that reduces accidents, increases cleanliness, attractiveness and comfort, production and improves employee's morale and public relations.

2 STATUTORY PROVISIONS

Sections II to 20 on health and 42 to 50 on welfare under the Factories Act 1948 and the respective rules 16 to 53, and 69 to 83B under the Gujarat Factories Rules 1963 must be referred for detailed provisions directly or indirectly concerning good housekeeping.

For cleanliness, a factory is required to keep clean and free from effluvia from any drain, privy, or other nuisance. Accumulation of dirt and refuse shall be removed daily by sweeping or any other effective method from the floors and benches of workrooms and from staircases and passages, and disposed of in a suitable manner. The floor is to be cleaned at least weekly by washing, disinfectant or effective method. Effective drainage, painting, white washing, varnishing etc., are also prescribed. Their report is to be maintained in Form No. 7. Provisions for disposal of wastes, effluents, dust and fume, adequate ventilation, lighting, workspace, drinking water, latrines, urinals, spittoons and facilities for washing, storing and drying clothing, for sitting, first-aid, canteen, shelters, restrooms, lunch-rooms and creches are also prescribed which should be checked during housekeeping inspection.

3 INDIAN STANDARDS

Some IS are : Air, clean, equipment, data sheet 12357, Air quality measurement, guide for units 9620, Air receivers for compressed air installation 7938, Air pollution control - glossary 4167,. Limits for 9005, measurement 5182, Air hose rubber - heavy duty 3557, light duty 9120, Air ducts, metal 655, Air compressor, mobile 6430, Vacuum pump - 6849, for vapour 8243, Vacuum pipe lines 8262, 9705, Vacuum producer 10678, Vacuum technology 4110, 8245, Vacuum filters 5675, 6034, Clean air equipment 12357, Cleaner - for foundry use 5841, 6443, Cleaning solution, porcelain 7983.

4 HOUSEKEEPING AND SAFETY:

Statistics of accidents suggest the items of bad or poor housekeeping and from them we infer the methods to improve housekeeping. Therefore they are considered first.

4.1 Typical Accidents due to Bad (poor) Housekeeping :

Statistics : See Table 5.8 in Chapter-5 for injuries in India in 1990 & 1991. Causation No. 10 to 15 give accidents due to (a) Hand tools (b) Falling bodies (c) Persons falling (d) Stepping on or striking against object (e) Handling goods/ articles and (f) Others. Thus total 84386 out of total 128099 (in 1990) and 42079 out of 60582 (in 1991) **clearly indicate that more than 65.87% and 69.45% accidents in India were due to the causes of bad housekeeping.**

See in Table 5.22 of Chapter-5 for industry and cause wise accidents in Gujarat in 1994. Considering Causation No. 123 to 131, in the last row of total, the accidents figures are as follows :

No.	Causes	Total Accidents
1	Others in machinery not moved by mechanical power.	511
2	Use of hand tools.	710
3	Struck by falling bodies.	980

4	Persons falling from height.	506
5	Persons falling on the flat.	474
6.	Persons falling into pits, excavation etc.	338
7.	Stepping on or striking against objects.	1472
8.	Handling goods or articles.	949
9.	Others.	3342
	Total	**98282**

Comparing with the total of all accidents 15683 this gives 59.18%. This clearly indicates that about 60% accidents in Gujarat (in 1994) were due to the causes of bad housekeeping.

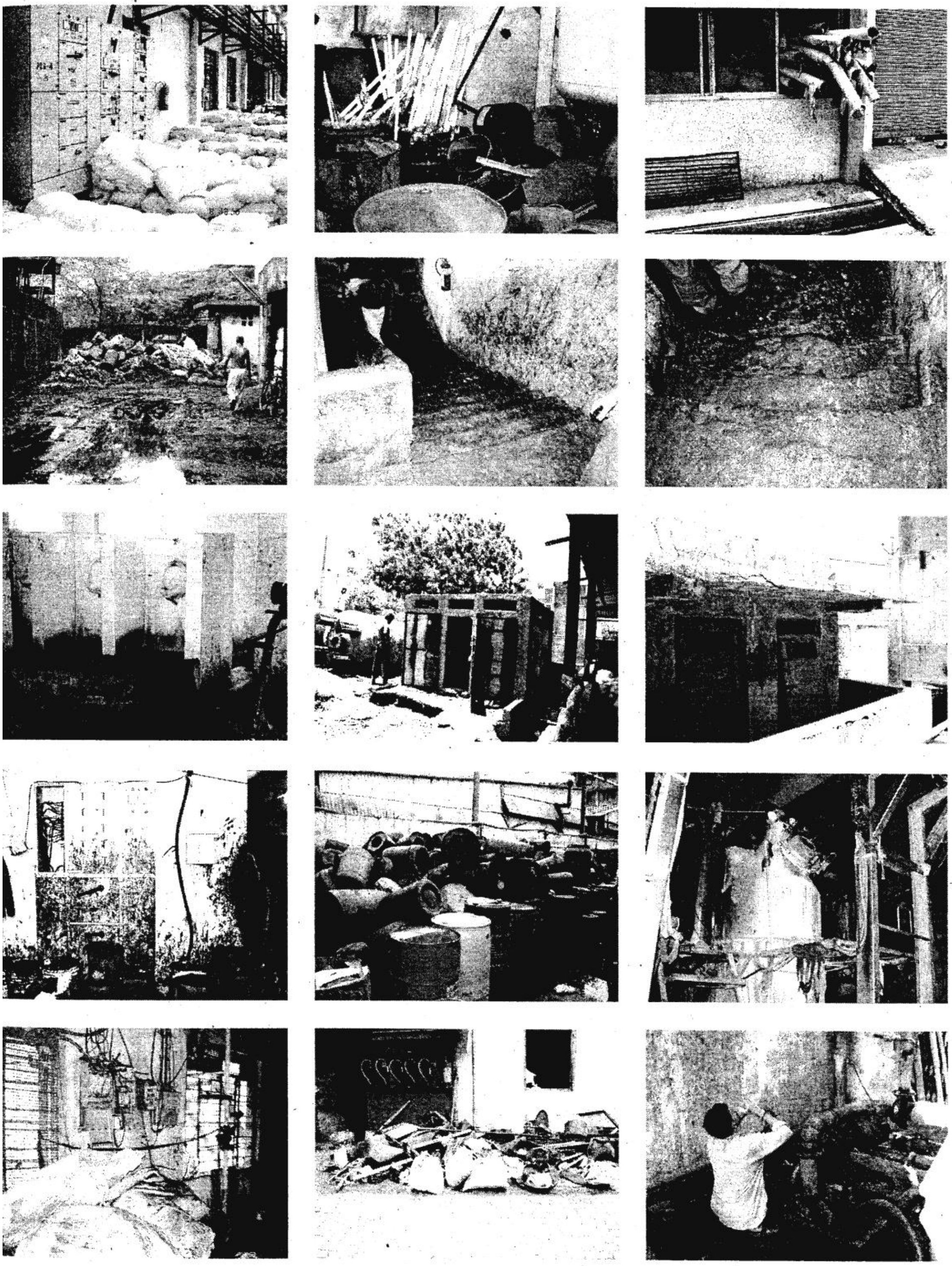
The Causes of bad housekeeping : These are well evident from above tables. The causes contributing the maximum accidents are :

1. Stepping on or striking against objects.
2. Handling goods or articles.
3. Struck by falling bodies.
4. Persons falling from height.
5. Persons slipping on the floor.
6. Use of hand tools, and
7. Others or miscellaneous.

The details or sub causes can be had from the actual accident reports. But some are as under :

Accidents due to poor or bad housekeeping i.e. their causes are : Striking against or falling over machine parts, materials or other obstructions left lying in passageways, cuts from objects left protruding from benches and especially on construction sites, punctures by nails protruding from objects or lying anywhere, falls on floor left slippery, greasy or damp, badly stacked materials, fires due to accumulation of combustible waste or leakage of flammable materials, cabinet drawers left open, dangerous dust or chemicals on floors and not cleaning them quickly,, congested aisles, no toe-guards or hand rails, overloaded waste containers, broken lockers and washrooms, dirty and unsafe walls, ceilings and windows, lint and dust on bearings of machines, tools left on machines or walkways, poor lighting, unsafe handling of chemicals; spillage of oil, grease, acid etc. on floors, pipes of air, water, steam and oil not properly maintained, no marking of safety and traffic signs, signals, loose or unsafe wiring etc. These should be the targets of planning for good housekeeping.

4.2 Indicators of Bad Housekeeping :



It is essential to know the items of poor or bad housekeeping so that they can be recognised, detected and removed. See Fig. 8.1. Such indicators of poor housekeeping are many and a list may become long. Some main indicators are listed below :

1. **Objects & Materials on Floor :** Excessive material, waste, debris, tools lying anywhere, congested aisles, walkways and workplace, spillage of oil, grease, acid etc., dropped or thrown down materials and disorderly piled material as obstruction.

2. **Poor Storage Practices :** Unsafe store design and unsafe piling i.e. too high or improper piling, overloaded waste bins, storing in aisles or obstructing doors, passage ways, storage of excessive material in work room.

3. **Equipment out of Place :** Wrongly parked vehicles, trucks, trolleys and wrongly placed tools, equipment, material, ladder, wire ropes etc. where they should not be.

4. **Dirty walls, windows, ceilings, floors etc. :** Dirty walls, windows, ceilings, floors, lighting fixtures, lint and dust on bearings or moving parts, open locker/drawer, slippy or dirty washrooms, latrines, urinals, canteens and workplaces.

5. **Poor waste disposal system :** Failure to provide receptacles or containers for waste and scrape, overflowing pans, dripping containers and unsafe handling of cutting oils etc., inadequate or leaking exhaust system, scrubber, treatment plant etc., emission of gas, fumes, vapours, accumulation of dust and no provision for cleaning device.

6. **Fire Hazards :** Accumulation of rubbish, oil, oil soaked rags or cotton waste, paper and packing material, substances causing spontaneous ignition e.g. dusts, oils, solvents, fertilisers, sugar, leather scraps, jute, hemp, hay etc., uninsulated, hot piping, hot bearings, sparks, welding-cutting in flammable area or unsafe manner.

7. **Chemical Hazards :** Nowadays chemical factories are increasing and workplace pollution due to chemical exposure is also increasing. This spoils the atmosphere and housekeeping. Splashes, leakage, dripping and escape of chemicals pose danger to health and safety and result in bad housekeeping. Acids, alkalis, solvents, pesticides and many dangerous chemicals change the colour and status of a factory. For details see Chapter-18 &19.

8. **Others :** Poor lighting, dark colours, poor ventilation, noise and vibration, broken tools, ladders, stools etc., open or loose electric wiring, no hand railing, no toe guard, no machine guarding, no fencing on pits, platforms and floor openings, drawers left open etc. -

From above discussion keys to good housekeeping are inferred as under - :

1. Cleanliness of floors, buildings & equipment.
2. Proper and speedy disposal of scrap, waste and surplus materials.
3. Keeping each object in its designated place and returning after work.
4. Sufficient work' areas, exits, walkways, aisles etc.
5. Orderly arrangement of material, process, machine, tools and equipment.
6. Good lighting, colour and ventilation.

4.3 Benefits of Good Housekeeping:

If the need, benefits, usefulness, results, advantages or effects of good housekeeping are known or explained in the beginning, it helps to provide zeal to maintain it. Therefore they are explained below. Good housekeeping increases safety and productivity as under:

1. It is an essential routine support to industrial safety and health.

2. A large number and wide range of accidents due to bad housekeeping can be eliminated by good housekeeping.

3. It aids to good maintenance and working as complementary to it and increase overall safety and productivity.

4. Clean, hygienic and safe plant environment increases attractiveness and morals of the employees.

5. Machines, tools and equipment work better in clean condition and boost up the workmanship.

6. If tools are placed in easy to find manner, job; run smoothly and give good results.

7. Clean and well maintained floors, stairs walkways, doors, windows, lifts, latrines urinals, washing facilities, furniture, records dresses, first-aid and protective equipment and proper layout of materials, tools and process flow certainly avoid many accidents.

8. Constant monitoring and control of hazardous chemicals, their processes and emission; minimise many hazards.

9. Much floor space or area is utilised because o proper access to machines and equipment for cleaning and maintenance purpose.

10. The fine and sophisticated instruments equipment and personal protective equipment give better results when kept in good and deal condition and checked regularly.

11. Accidents due to stepping on or striking against objects or fall of persons and objects, stumbling tripping, bumping, body caught between object etc. are well controlled.

12. Time spent in locating tools and appliances and wastage of time is controlled resulting in increase of efficiency.

13. Damage to person and property likely to occur due to disorder is reduced resulting in loss control.

14. Conservation of materials/property/energy results due to less scrap and spoilage and improves better capacity utilisation.

15. Loss due to misplacement of costly items would be reduced due to proper placement and order.

16. Losses due to out break of fires could be controlled to a great extent by proper housekeeping. Minimisation of losses on this account alone justifies the effort.

17. Values of materials and machines do not get reduced when they are properly maintained.

18. Overall life and utility of plant, building and equipment are increased due to good housekeeping.

19. Majority of small fires result from and spread by poor housekeeping conditions. Sources of ignition due to oily cotton waste, solvent spillage, oil dripping, friction, sparks, flames, smoking etc. can be prevented by good maintenance and housekeeping. See Part 6.5.

20. A clean and well maintained plant can be operated at a lesser cost.

21. Production increases due to reduced obstacles and wastage of time and speedy availability of material, equipment, tools etc.

22. Repair and maintenance work become easy due to easy access and clean space availability.

23. Aisle traffic becomes smoother and speedy. Truck/trolley collisions become less.

24. Employee moral is boost up due to orderly things, neatness and cleanliness, sufficient space to work, good lighting, colour and ventilation and mostly due to reduced possibilities of accidents and injuries.

25. Outside visitors, market people. Government authorities, local community and the top management are attracted and overall image of ' the company rises up.

Some examples of good housekeeping are shown in Fig. 8-2. .

5 METHODS OF GOOD HOUSEKEEPING:

After knowing the benefits of good housekeeping ' as above, the methods of good housekeeping are to be devised. Such methods are many. A few are given below:

5.1 General Considerations :

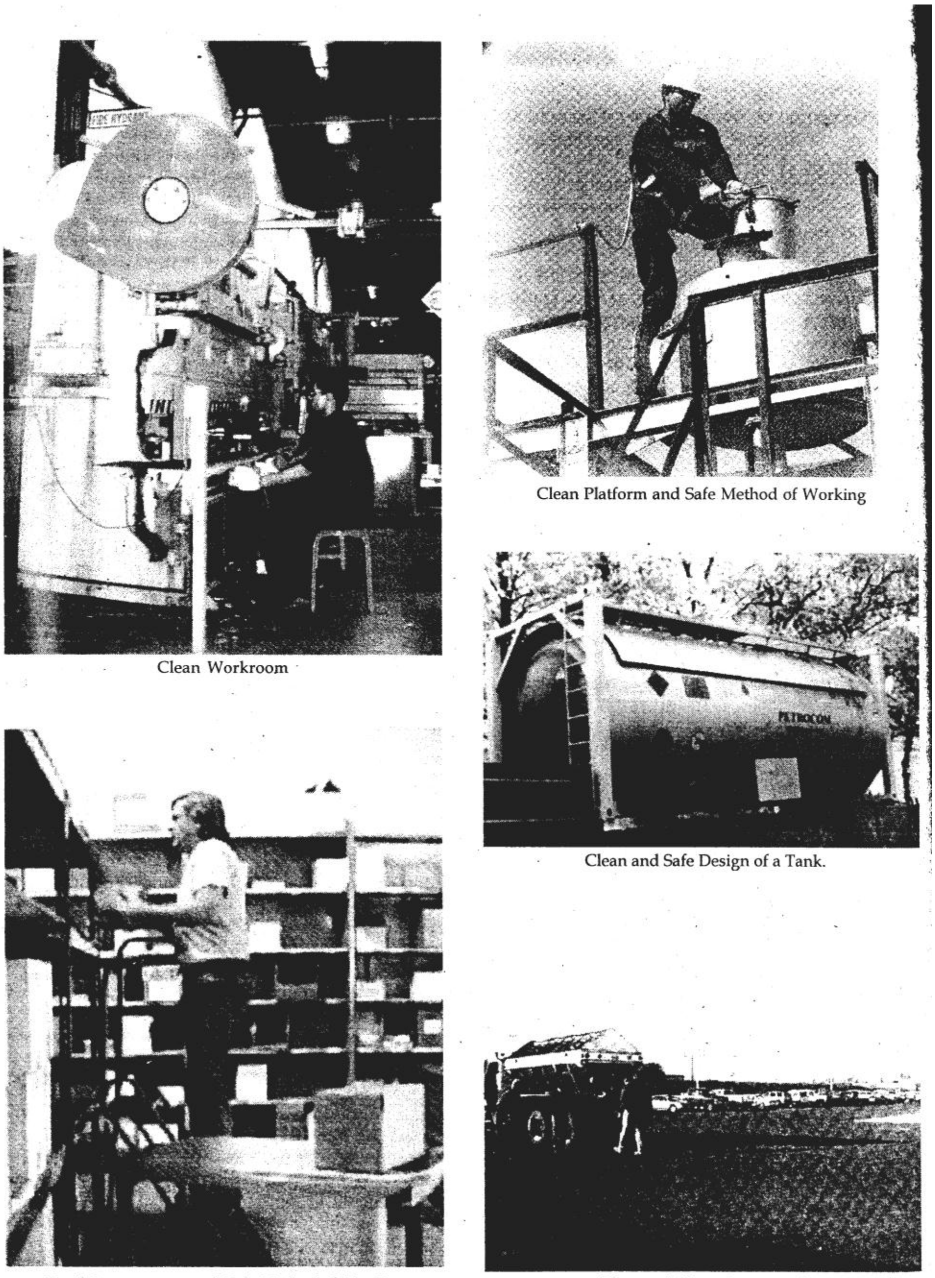
The 25 items listed in Part 4.3 suggest general considerations or essentials for good housekeeping in a factory. In short, they should include proper placement and use of hand tools, materials, equipment, clear and unobstructed workplaces, aisles stairs etc., speedy disposal of waste, scrap, splashes and obstructions, safe means of handling goods or articles, fenced platforms, floor-openings and wall openings to prevent fall accidents, removal of possibilities of falling bodies, provision of sufficient containers for waste collection, avoidance or fencing of sharp edges, corners etc., safe and efficient cleaning methods, good lighting, colour and ventilation, proper marking and identification, protective equipment to cleaners and maintenance men, special areas for storage of raw materials, finished product, tools and accessories, racks for hand tools or implements above work-benches, under bench drawer for storage of small personal possessions, devices on machines to prevent deposit of oil, water etc., cleanliness of surrounding floors, drainage, channels etc, special cleaning gangs with necessary cleaning materials and equipment, daily and weekly cleaning schedules, regular arrangements for removal of waste and emptying of waste containers, prevention of debris and clutter under benches and machine parts and special precautions depending upon the nature of industry.

5.2 Disposal of Scrap and Trade Wastes :

This is the major part of good housekeeping. Estimation of probable wastes in advance and planning for suitable means of their collection and disposal in the most economical and efficient way is desirable. Separate sweeping service, sweepers with equipment, waste and scrap receptacles with cover, overflow pans, chip screens, chip catchers, chutes, exhaust and dust collection systems, drain for liquid splash, vacuum cleaners, waste containers, methods of their transport and disposal, schedules of daily, weekly and special cleaning need attention. Such general service is not expected to pick up scrap, spoiled work, refuse, processed parts or tools. The plant workers are responsible for keeping such items off the floor. The supervisor/foreman is responsible for orderliness and cleanliness of his area. Instructions regarding hazard of cleaning up in Part 6.4 should be followed.

Hazardous waste should be disposed of with care. Fire hazards of combustible waste should be prevented. Chemical wastes should be rendered harmless before being disposed or dumped. Strong acids should be neutralised and not poured in open. Poisonous materials, explosives, radioactive waste requires special procedures for safe disposal. The workers should be properly trained for safe disposal.

See Chapter-18 for pollution hazards and control, and Tables 16 & 18 of Chapter-32.



Clean Workroom

Clean Platform and Safe Method of Working

Clean and Safe Design of a Tank.

Good Arrangement and Safe Method of Working

Neat and Clean Compound

Fig. 8.2 Examples of Good Houskeeping

5.3 Prevention of Spillage

Oil, coolant, water and chemical splashes on floors are routine phenomena in industries. If they are not quickly and properly cleaned of, they cause slips falls, burns etc. If the chemical is flammable, explosive, reactive or toxic, additional danger is added. The basic effort should start from the design of appropriate floor viz. acid proof lining, rubber lining etc., drainage system for flow collection, covering on gutters, splash guards as on jigger machines (for dyeing textile), oil or coolant screens and collection trays, drip pans to collect drippage from leaky valve, line etc. Damage to floors or such devices should be repaired immediately. Workers should be trained to remove such spillage as early as possible. Appropriate neutraliser (caustic, lime, soda, sand etc) and absorber should be used.

5.4 Marking Aisles and other Locations:

The aisles, gangways, catways, internal roads and passages, stairs, ramps and working platforms also cause accidents due to improper marking, unsafe condition and frequency of persons passing on them. Therefore they must be properly marked, equipped with necessary handrails, footholds, fencing, lighting etc., and kept clean, dry and unobstructed.

Similar marking and up-keeping of other locations such as loading-unloading or receiving-dispatch points, parking area, store area, electrical switch yard, tool room, rest-room, lunch-room, sanitary block, washing centre, drinking water centre, first-aid centre, assembly points, emergency equipment points, fire protection points, environment monitoring points, effluent points, scrubbers, dust bins, waste collection centres, dumping yard, scrap yard, storage tanks etc., also necessary for good housekeeping.

Truck, trolley, cart and moving equipment should not be left on the way to cause obstruction or harm. Aisle width should be sufficient to contain traffic. Its portion for pedestrian traffic should be distinctively marked. Bright coloured lines (e.g. zebra strips) can be used for pedestrian crossing. Yellow strip should be marked on the edge of level difference. Mirrors should be placed to judge or see the man or material approaching from the other side not otherwise visible.

Sufficient storage space should be designed and provided to contain full inventory. Design of chemical stores needs much attention. Orderly locations, placements and marking help much for better housekeeping.

5.5 Tool Housekeeping:

Disorderly placed tools or absence of holding device is a common phenomenon. Orderly arrangement of tools in crib (rack or box) or in a tool room and regular checking of tool condition and necessary repairing are most essential. Necessary tool box, pens, holders, racks, shelf etc. should be provided with the machine and also in the tool room.

A fixed tool holder (tray) with machine or a movable trolley holding a set of tools, jigs, parts etc. should be provided.

Tools placed at their proper place do not waste time in searching them. The workers and supervisors should insist for such habit.

5.6 Use of Colour as an Aid :

The subject of colour is separately dealt with lighting in the next Chapter. It is important to note here that proper colour selection for walls, ceiling, passageways, machines, piping, railings, fencing, guards, boundaries, fire equipment, lifting machines, warning signs, danger zones etc., play vital role in improving housekeeping and safety. Statutory or IS for colour-code, if any, should be followed, otherwise the selection should be based on the best effect and necessary contrast.

See Part 7 & 8 of Chapter-9.

5.7 Cleaning Methods :

Normally employed cleaning methods are cleaning by broom or brushes, vacuum cleaning, washing by water or steam, air-jet cleaning, super-sucker to suck spillage, blockade or choking etc.

Broomstick cleaning's useful for a limited area and where no much dust is accumulated. Air-jet cleaning is also not desirable in open workplace, though it is effectively useful to clean inner sides of any vessel, pipe, tube, equipment etc. But while doing so, air-pressure should be regulated (controlled) dust masks must be worn and proper dust collector should be provided.

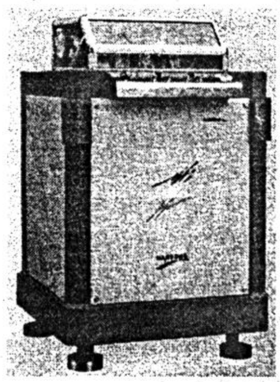
Brushes are useful to clean sticky material. Wire brushes are employed to clean hard and metal surfaces or deposits. Soap or detergent powder may be used with water.

The best cleaning method is by vacuum cleaning because it does not push or cause to fly dirt or dust here and there but pulls inside the dust chamber which can be emptied at a desired place. This method has the least health hazard as it does not allow dirt or dust in atmosphere. It can suck dust from air also. Vacuum cleaners are available of different sizes and capacities. They may be portable or fixed for particular location, machine or system.

Local exhaust ventilation (LEV) is an improved design of vacuum cleaning device and effective engineering control to collect dust or waste from near the source of generation. Its application in industry is very wide and instead of cleaning device it is considered as an integral part (safety device) of .the machine or equipment to which it is attached. Carding machine (textile), buffing and polishing machine, grinding wheels and many dust or gas generating processes (e.g. acid cleaning) are provided with such local exhaust ventilation or dust collectors. See Table 18 in Chapter-32 for guide to select dust collectors.

Portable cleaning device

In chemical and metal industry, special cleaning agents - HGI, H,O,, HP etc. - decreasing agents and organic solvents are used .to clean metal surfaces and piping. Purging by air or nitrogen is also utilised to clean vessel, equipment, pipeline etc.



Trolly mounted portable cleaning device is available to clean floors, walls, vehicles, storage vessels, machine tools, construction machinery, factory shade etc. High pressure jets are used to clean effectively. It removes dust, scale, oil, grease, rust etc from the surfaces. Plain water or water mixed cleaning agent can be used.

Parts washer is also available to clean small parts of labouratories, auto mobiles, metal, plastic and glass, general machinary, service stations etc. Cleaning is done in enclosed chamber. It removes oil, grease, rust, dirt, paint, scale, scrap, burrs etc. Washing pressure is kg/cm2.

6 MANAGEMENT OF GOOD HOUSEKEEPING

Good housekeeping is not possible without management policy, planning, efforts, responsibility, follow up and overall co-operation of all plant people. -This is explained below :

6.1 Management Policy and Responsibility :

Like Safety, health or quality policy, the top, management must establish, declare and implements housekeeping policy emphasising that

1. Dirt and disorder are always evidence of waste of materials, time, energy and effectiveness.
2. Regular cleaning of dirt and maintaining orderly things may be a tough job, but it is the management's responsibility.

3. Good housekeeping reduces accidents and increases safety, productivity and morale.
4. Working in dirt, dust and disorder increases cost and decreases workers' comfort,
5. If you can't manage to have cleanliness and order, you can't manage your department.

Management must formulate such policy, encourage supervisors to' implement it and help removing beliefs like 'That is naturally dirt/,'IP cannot be avoided', 'How many times to clean it ?'

If top management, will accept this policy and responsibility, others will follow it. Housekeeping programmes must be 'planned, promoted patiently, regularly and carefully.

6.1.1 Planning and Follow up :

Merely wishing good housekeeping is not sufficient. Certain policy must be established and followed. Aids and equipment necessary for good housekeeping must be purchased. The management must understand the results of bad housekeeping and must accept responsibility for good housekeeping

Planning and follow-up should include -

1. Deciding policy and technique for good house keeping.
2. Proper layout of work area.
3. Marking of aisles, ways and storage areas.
4. Cabinets and holders for tools and equipment.
5. Storage arrangements for materials.
6. Containers for materials in process.
7. Efficient sequence of operations to avoid bottlenecks.
8. Anticipation of waste, scrap, dust, spillage, splashes etc., and inclusion of methods of their control stated in Part 5.2.
9. Efficient transportation of raw material, finished:; products and refuse. Use of mechanical feeding belt conveyor etc..
10. Efficient cleaning methods including vacuum cleaners etc., and without interrupting the production schedule.
11. Necessary training of workers.

This is a sample list which may be modified according to the particular requirements of a plant.

Good housekeeping cannot be left to the unplanned activities of persons employed. It is a management technique and it should be laid out in such a way that it is easy for order and cleanliness to be observed.

A good housekeeping committee, competition, rewards and individual and group incentives for good housekeeping play an important role to increase and maintain motivation for housekeeping.

6.1.2 Overall Co-operation :

After setting up of policy and programme for good housekeeping and division of responsibility for implementation and compliance up to the floor level, it becomes necessary that all plant people must wholeheartedly co-operate for the success and achievement of good housekeeping in every corner and at all times.

Supervision and cleaning arrangements for working areas and sanitary facilities are essential. It is necessary to maintain interest of all plant people for such co-operation. Motivation and competition bind the co-operation. Co-operation of safety engineer/officer, supervisors and workers in their respective areas is most important for overall efforts of good housekeeping. They are explained below in brief.

6.1.3 Housekeeping Contests :

To stimulate the interest by an element of competition, many times housekeeping contests are arranged between different departments or groups of a factory or between different factories on district or state level where organisations like National or State Safety Councils take interest.

Committees are formed to inspect participating departments. Representatives from different departments should be co-opted by the safety department.

Inspection may be limited to the period of contest only or it can be made regular by making it monthly, bi-monthly or quarterly. The visit should be unannounced so that real picture can be seen and regularity in housekeeping may be developed.

An award, prize or incentive may be given to the winning department (to its leader or to all employees of that department). Small gifts of attractive or useful nature may also be given. Such awards should be given m a function of all employees and by the hands of the top executive. Supervisors of the winning department should be specially complemented. Their encouragement is most important to get the work done.

6.1.4 Employees Assignment:

It is the management's responsibility to assign sufficient employees to carry out routine daily housekeeping job. Mostly such work is given on contract and company employees believe that housekeeping is not their job. However where this job is assigned to company employees, the picture is not good at some places. Because of unionism, company employees are less duty-conscious and not that much regular as the contract workers. Such tendency is diverting more -and more jobs to contract workers. Housekeeping, gardening, security, transport, canteen and other welfare activities are such jobs.

Depending on number of latrines, urinals, bathrooms, washing facilities, canteen, rest room, lunch room, medical centre and size of work areas, compounds, roads, godowns etc., sufficient number of employees should be allotted for housekeeping work. If more than one shift are running, appropriate staff in each shift is necessary.

If sufficient manpower is not assigned looking to the area and hours of work, good housekeeping cannot be achieved. Economy or shortage in manpower will result in bad housekeeping. But because of increasing cost of manpower, compulsion of reduction in cost of production in competitive market and availability of cleaning machine replacing manpower, proper balance has to be maintained in assigning employees for housekeeping.

However, it should be borne in mind that dirtiness and bad housekeeping create health and safety problems and may increase medical expenses, absenteeism and HR problems. Therefore employee assignment for housekeeping job needs careful consideration and due weightage.

Instead of solely depending on or waiting for employees for housekeeping job, if each company employee feels his own duty to clean and maintain own workplace, own machine and own table, it will be more meaningful and useful. 'Housekeeping is everybody's job' should be the concept. 'Work is worship' is not a slogan, it is to be practised.

6.2 Safety Officer's Role :

A safety officer has to play an important role by

1. Suggesting the best housekeeping policy, procedure and equipment to the top management.
2. Co-operating in finalising the policy and planning including preplanning, space requirements and facility requirements for good housekeeping.
3. Implementing the policy, procedure and programmes through supervisors, workers and all concerned throughout the plant.
4. Advising and assisting all plant people for their co-operation in good housekeeping efforts.
5. Solving the problems by appropriate design, layout, planning and purchasing equipment for good housekeeping.
6. Arranging supervision, competition, award and incentive schemes to improve housekeeping and maintain interest.
7. Designing and arranging regular and special inspections, checklists, rating forms and records for good housekeeping.
8. Paying more attention on all points mentioned in other parts of this Chapter and particularly on (a) Clean premises, machines, equipment and orderly layout (b) Clean and hygienic sanitary facilities, bathrooms, cloak-rooms, mess rooms etc. (c) Storage places for raw materials properly classified (d) Cabinets and holders for tools and portable equipment (e) Containers for materials in process and products (f) Prompt removal of dirt, dust, refuse, splashes, wastes and unwanted 'materials (g) Careful training of workers and (h) Maintenance of plant 'including lighting, painting and motivation for good housekeeping.

6.3 Supervisor's Role :

For good housekeeping the interest and cooperation of the supervisory group is more important as it is the more responsible group and more close to the working conditions and workers. All supervisors must provide initiative and leadership for daily attention of the workers on cleanliness and orderliness of workplace, machine, equipment, tools, materials etc. in their control.

They have to carry out the management policy, programme and maintenance of good housekeeping in their areas. They should take part in competition of housekeeping and try to win awards for that. They can contribute much to boost up workers' morale, attitude and enthusiasm towards their day to day checking and. efforts for good housekeeping. They have to obtain co-operation from all workers for their success. If any award for rating standards are prescribed for their superior performance, they should explain the workers how to achieve them. They must pay constant attention on all items of removing bad housekeeping and maintaining good housekeeping.

6.4 Workers' Role:

No success is possible without workers' efforts and co-operation for any safety or housekeeping programme. This should be taught to them from their initial training. Creating and maintaining their interest is most important. It is the management's skill and workers' wish to do it. They have to implement the policy and checklist given to them for good housekeeping. A list of items of daily and periodical checking should be prepared, displayed and followed up accordingly. It should contain the items given in

Part 4.3, 6 & 7 of this Chapter, but selective for their job and place requirement. To keep their own place of work, machine, equipment, tool etc., clean and in working order is in their interest. *Nobody else can keep their things so clean and in order as they keep for themselves. Daily they should spare a few moments for cleaning up.*

Hazards of cleaning up in proximity to moving machinery must be informed to workers. The workers for such work should be well aware of -

1. Risk of entanglement, use of compressed air, electric shock, chemicals, cuts from scrap metal, swarf or broken glass etc.
2. Skin affections and dermatitis due to detergents, oils and cleaning materials.
3. Need to wear personal protective equipment for protection from striking by objects, stepping over sharp edges, handling such material or facing dust, fumes, gases, splashes etc.
4. Need of washing, cleaning, first-aid treatment and vacuum cleaning when required. To keep top cover and bottom (drain) valve open while cleaning any tank from the top.

6.5 Role of Maintenance:

The term **maintenance** maybe mixed with the term good housekeeping and therefore their difference should be understood.

Maintenance covers the work done to keep building, plant, equipment and machinery in safe and efficient working order and in good repair, the upkeep of all sanitary and welfare facilities and the regular painting and cleaning of walls, ceilings and fixtures.

Good Housekeeping includes day-to-day cleanliness, tidiness and good order in all parts of undertaking. Good housekeeping is not possible without good maintenance and vice versa. Thus both are complementary.

Preventive maintenance is a scheduled or regular periodical maintenance of plant and machinery. Its purpose is to prevent sudden or accidental failure, stoppage or breakdown of plant and machinery. Without waiting for breakdown or failure, periodical oiling, greasing, tuning, changing of parts, testing and examining keep the machinery in efficient working condition, smooth running without excessive noise and vibration, leakage etc and it helps to maintain good housekeeping. Sometime 'shutdown' is planned for such preventive maintenance.

Productive maintenance is for the purpose of improvement in production. If speed or output is decreased, noise, vibration, out running, reject, breakage, leakage etc. may increase, then such maintenance is carried out to remove these losses. Even without such losses or disorder, modification is carried out to boost up or increase the production rate or to achieve desired quality or quantity of products.

Breakdown or corrective maintenance is compulsorily required when plant or machinery stops due to breakdown, sudden failure, stoppage, accident or leakage etc. Then without urgent repair, restarting is not possible, otherwise it adversely affects housekeeping.

See Part 8.5 of Chapter-4 and Part 15.8 of Chapter-18 also.

Thus role of any type of maintenance is to improve safety, productivity and housekeeping.

7 JAPANESE CONCEPT OF 'FIVES'

A Japanese concept for good housekeeping states ‘Five S’ as under -

1. **Seiri** : This means segregation. Dirt, dust, rubbish and all unwanted wastes or material should be collected and segregated first.

2. **Seiton i.e. arrangement.** There should be effective arrangement of safe disposal of segregated wastes. This also includes preventive ' arrangement such as local exhaust ventilation, dust collectors, vacuum cleaners, guards, covers and devices to reduce noise, vibration, leakage, spillage etc.

3. **Sciso or cleaning.** Main activity of good housekeeping is cleaning. It includes cleaning of floors, walls, ceiling, sanitary and welfare facilities, parts of plant and machinery, PPE and other equipment, tools, lighting fixtures, lamps, tubes etc.

4. **Seiketsu i.e. maintenance** of standard. This suggests compliance of statutory provisions and national or international standards for safety, quality, cleanliness and environment. Maintenance should also include all activities mentioned in Part - 6.5.

   For example, maintenance of standard mentioned in Schedule 2 of the Factories Act and Form 7 and 37, GFR, indicates status of housekeeping.

   For statutory provisions see Chapter 27 and 28.

5. **Shitsuke or Discipline** - This indicates duty of everybody to follow rules, regulations, instructions, notices, orders, appeal etc for maintaining good housekeeping and safety.

   Notices to spit in spittoons only, not to throw rubbish anywhere, not to smoke in flammable areas, not to run machine at over speed, not to open guard or safety devices without authority, not to waste water, power, oil etc, to follow traffic and safety rules, to wear ear protection in high noise area and other PPE for specific woik,to use proper tools and equipment etc should be strictly followed as discipline. Motivation is required for self discipline. For maintenance of good housekeeping discipline plays a vital role.

8 INSPECTION AND CHECKLISTS

8.1 Inspection Rating :

Purpose of housekeeping inspection is to detect the items or causes of bad housekeeping to remove them. Such inspection may be by an individual such as supervisor, inspector, plant in-charge, safety officer, superintendent or by a housekeeping committee, safety committee or team consisting some of them as per requirement. Instead of inspecting own department it is advisable to inspect other's department to avoid any favour or bias. Monthly inspection is sufficient. It may be weekly also.

For a systematic inspection, a checklist should be prepared covering our own plant details and specific requirements. Condition ratings should also be fixed for easy marking or evaluation. A specimen checklist with score (marks) 0 to 10 is described below:

A. **Excellent Housekeeping** (Score 10.0 to 8.1) General appearance very neat and tidy. Gangways very clean. Pieces of cotton waste, papers etc., not seen on the shop floor. Materials stored in very orderly manner. Portable machines, hand tools, equipment etc., kept tidily and in orderly manner. No leakage of compressed air, oil or any material. Roofs, fixtures and fittings etc., free from cobwebs.

B. **Good Housekeeping** (Score 8.0 to 6.1) General appearance clean. Gangways and shop area fairly clean. Most of the materials stored properly. Machines, equipment kept clean. No cobwebs on roofs, fixtures and fittings.

C **Average Housekeeping** (Score 6.0 to 4.1) General appearance satisfactory.. Gangways free from materials, cotton waste or pieces of papers. Cleanliness on the remaining floor area average. Machines and equipment kept reasonably clean. Roofs, fixtures and fittings not thoroughly free from cobwebs.

D. **Below Average Housekeeping** (Score 4.0 to 2.1) General appearance not satisfactory. Gangways partly blocked with materials. Few pieces of cotton waste seen on the gangways. Other shops are not clean. Machines and surroundings not clean. Cobwebs on roofs and walls, fixtures and fittings not clean.

E. **Foot Housekeeping** (Score 2.0 to 0.0) General cleanliness much below the required level. Gangways blocked with materials and pallets. Pieces of papers, cotton waste etc, seen on the floor. Machine and equipment not clean and dripping with oil and grease, etc. Materials not stacked properly.

Such items and rating may vary. They should be devised according to need.

8.2 A Model Checklist :

Housekeeping checklists are many and they may differ for details. Plant in-charge should design its own checklist best suitable to it. Such checklist must cover all statutory points. A sample checklist is given below. Write replies and remedies against each item. -

1. **Plant Layout :** (1) Are Size, shape, location, construction and layout of building, machinery and other facilities permit the most efficient and orderly utilisation of men, materials and machinery ? (2) No doubt this aspect should be considered at the design stage, still some improvement can be expected with slight modification and adjustments in die old layouts. Is such modification necessary for good housekeeping?

2. **Storage :** (l) Are materials or items stocked too high? (2) Arc stairs, fire escape exits? Fire extinguishers obstructed? (3) Are aisles free from obstructions? (4) Are items over hanging or protruding so as to cause injuries? (5) Are bin cards and tally cards displayed for identification?

3. **Interior Arrangements :** (1) Are machines, benches, cabinets, racks so arranged as to facilitate good housekeeping? (2) Are aisleways marked? (3) Are marshalling areas so located as to encourage their use? (4) Is colour or white washing in attractive and appealing condition? (5) Are sitting facilities provided and furniture in good condition?

4. **Machinery and Equipment :** (1) Is machinery/ equipment well maintained and colour coded? (2) Is there any leakage of gases or spillage of liquids? (3) Is there any deposition of dust or other contamination on them? (4) Is moving machinery well guarded? (5) Are they causing noise or vibration ?

5. **Electrical fitting and illumination :** (1) Are cables or wiring loose or hanging? (2) Are sockets, plugs provided and cables are of standard requirement? (3) Are all areas sufficiently lighted to reveal dirt obstructions and hazardous conditions? (4) Are there burned out bulbs or sockets without bulbs or light shades hanging? (5) Is there dirt or dust on the control panel or instruments? (6) Are trenches full of rubbish? (7) Are all earthings all right?

6. **Floors, drains, pits and manholes :** (1) Are floors uneven and dirty? (2) Are drains full of waste and choked? (3) Are drams and manholes open? (4) Are floors dirty and slippery? (5) Are maintenance materials like gaskets, nuts, bolts, nails etc., scattered? (6) Is cotton waste or oily material thrown on the way? (7) Are pits and opening fully covered or guarded?

7. **Platforms and stairs :** (1) Are control valves at height provided with platforms and ladders? (2) Are platforms and staircases provided with hand railings and toe guards? (3) Are ladders provided with handrails? (4) Is ergonomic design followed ?

8. **Sanitation and ventilation :** (1) Is ventilation adequate throughout the area? (2) Is there indication of rodents and insects? (3) Are personnel eating in work areas creating in sanitary conditions? (4) Are urinals and bathrooms stinking and require white washing and disinfectant spraying and cleaning? (5) Are unnecessary odour prevalent? (6) Are proper receptacles provided for the waste?

9. **Fire extinguishing System :** (1) Are all extinguishers charged of correct type, in their proper place and readily accessible? (2) Are plant personnel trained in fire fighting?

10. **Safety and First-Aid :** (1) Are required type of safety appliances available, kept in proper places and well maintained? (2) Are first-aid boxes or eye irrigators kept at proper places and well maintained? (3) Are persons trained in the use of first-aid appliances and first-aid practices?

11. **Yard Areas :** (1) Is material properly segregated and kept in earmarked areas? (2) Is proper dunnage and pallets provided wherever required? (3) Are identification boards displayed on each material? (4) Are areas free from unwanted growth of grass or shrubs?

12. **Display and Identification :** (1) Are process flow sheets and circuit diagrams displayed at appropriate places? (2) Are lubrication and maintenance schedules displayed? (3) Are safety, first-aid and hazard posters and charts displayed? (4) Are equipment identified properly?

Another checklist for working conditions and productivity in small and medium-sized enterprises, suggested by ILO is given as Table-6 in Chapter-32.

9 HOUSEKEEPING OF SPECIFIC INDUSTRIES

Special nature of industry needs special items to be included for its housekeeping. Problems of housekeeping are not same in engineering, foundry and pharmaceutical factories. Some factories become more dusty and dark due to their processes. Chemical factories have special hazards. Therefore their specific points must be considered well in advance at the designing stage so as to facilitate easy housekeeping Rule 16 of the Gujarat Factories Rules gives a schedule of factories to which provisions of painting, white washing etc., are not applied. Blast furnaces, brick works, cement works, copper mills, gas works, iron and steel mills, stone, slate and marble works are exempted thereby. Simple washing, sweeping, brushing, dusting vacuum-cleaning etc., are required for them.

A **specimen checklist** for an engineering factory is given in Table 8.1 as a guide.

Table 8.1 : Weekly Check List for Housekeeping of an Engineering industry

Sr.	Check List	Yes or No.		Comments & Action to	Action By	Remarks

			be taken
1.	Shop/ Work Areas :	(15)	Is there leakage or accumulation of combustibles? Dykes provided surrounding tanks?
(1)	Is the floor swept properly and kept clean?	(16)	Is there any loose and hanging temporary wiring? Earthing broken?
(2)	Are the gangways & passages clearly marked and completely free of materials?	(17)	Are all instruction charts, sign boards, notice boards, etc. in position and kept up-to-date? Notices for 'no smoking", 'high noise area' etc. displayed?
(3)	Are the stairs/staircases, ladders swept properly? Is the approach clear?	(18)	Are the lavatory blocks clean & deodorised?
(4)	Are the drains kept clean and unobstructed?	(19)	Are the water coolers clean? Is there any water spillage?
(5)	Are the machines and equipment kept reasonably clean and guarded while working?"	(20)	Are fire protection appliance kept unobstructed?
(6)	Is shop free from accumulation of oil, grease, oily rags etc.?	(21)	Are the lockers & cupboards clean and kept in orderly manner?
(7)	Are the window glasses, north light' glasses and partition glasses clean?	(22)	Are first aid boxes at proper places ?
(8)	Are the roofs, walls etc., completely free from cobwebs?	(23)	Local exhausts and dust collectors properly working ?
(9)	Are lighting fixtures, fans etc., wiped and cleaned?	(24)	Lifting machines marked with SWL ?
(10)	Are tables, chairs, racks, cupboards etc., clean?	(25)	Rotating machines marked with notices of speed?
(11)	Is the shop clear from all the scrap and other unwanted materials? Is there proper location for discarding these?	**2.**	**Scrap Collection and Disposal:**
		(1)	Is die scrap and garbage collected nearly at one place regularly?
(12)	Are the raw materials stacked and stored properly and in orderly manner?	(2)	Is the disposal being done regularly/frequently as necessary?
		(3)	Is area in and around the shop/building kept free from accumulated packing, scrap & other materials?
(13)	Are there any wastage / leakage of water, electricity, fuel, steam, compressed air seen?	**3.**	**Use of Uniforms, PPE etc:**
		(1)	Do workers wear necessary uniform and PPE?
(14)	Whether lighting & ventilation is proper and clean?	(2)	Do they use proper tools and equipment ?

(To be used by the Shop Foremen / Section Heads)

Note : Please mention any other items (not included above) which require immediate attention or additional measures to be taken to improve housekeeping in your shop.

EXERCISE

1. Explain, State, Mention or Discuss :

1. Good and bad housekeeping.
2. Benefits or results of good housekeeping.
3. Statutory provisions regarding good housekeeping.

4. Indicators of poor housekeeping.
5. Various items of industrial housekeeping.
6. Various types of cleaning methods.
7. What will you include in planning and follow up for good housekeeping?
8. How are housekeeping contests helpful?
9. Safety Officer's OR Supervisor's role for good housekeeping.
10. Workers' role in plant housekeeping.
11. Three types of maintenance and their effects on housekeeping.
12. Contents of a model checklist for good housekeeping.

2. Write Short Notes on :-

1. Meaning of housekeeping.
2. Difference between housekeeping and maintenance.
3. Typical accidents due to bad housekeeping OR the Causes of poor housekeeping.
4. Disposal of scrap and trade wastes OR Location requiring marking.
5. Marking aisles and other locations OR Examples of good housekeeping.
6. Colours as an aid for good housekeeping.
7. Management's role for good housekeeping.
8. Employees' assignment for housekeeping.
9. Concept of 'five S' for housekeeping.
10. Checklist with rating for housekeeping.

3. Comment on following explaining whether it is true or not:-

1. Poor housekeeping is not the reason of accidents or injuries.
2. Good housekeeping has effect on safety and productivity.
3. Human 'factors and habits have nothing to do anything with housekeeping.
4. Orderliness is a part of housekeeping.
5. Housekeeping contests are of no use.
6. Safety Standards can be improved through good housekeeping.
7. Pre-planning helps housekeeping.
8. Safety Officer is not meant for housekeeping.
9. Maintenance has not to do anything to improve housekeeping.
10. Policy is not required for housekeeping.

Reference and Recommended Readings

1. ILO Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
2. The Factories Act and Rules.
3. Safety and Good Housekeeping by NPC, New Delhi.

CHAPTER – 9

Lighting and Colour

THEME

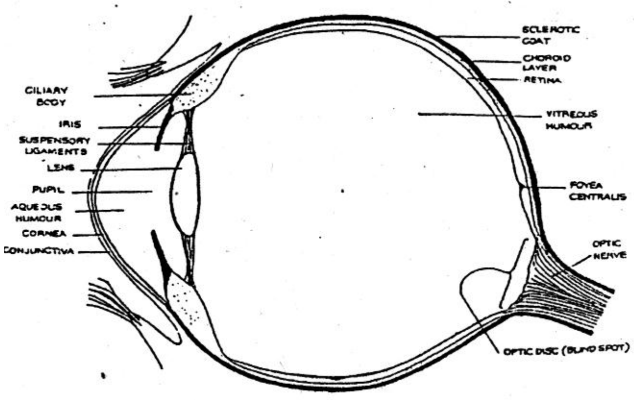
1 SIGHT AND LIGHT

Sight and Light are the supreme need of life. Without eyes, sight and vision, life is incomplete. In Part 8.2.4 of Chapter 6, a Sanskrut stanza is given explaining that a mirror is of no use to him who has no eyes. The first and foremost sense required and being utilised for human activity is sight.

The divine and powerful source of sight, light and life is the SUN whom we call 'Surya' and worship. It is the Sun only who is giving life to all of us and the whole universe, who throws ample light everywhere (if not obstructed) and gives sight to our eyes. Our artificial lighting is not at all comparable with its natural lighting, in terms of quantity, quality and cost.

The fulfilment of almost all tasks depends on proper visual perception and it is estimated that about 80% of the sensory information for any work performance is received by brain through eyes only. Ordinarily all persons put reliance on sight than on any other senses, because without sight it is difficult to understand and judge about any object or action. Thus the importance of eyes, sight, or vision must first be understood.

The human eye has visual acuity or an ability of accommodation i.e. the ability of the eye



Inner parts of human eye

to change its effective focal length to see or distinguish objects distinctly at. varying distances. Adaptation ability of an eye is its sensitivity adjustment effected after sufficient exposure to light (light-adapted) or darkness (dark-adapted). Dazzling conditions and frequent adaptation may cause visual fatigue and eye troubles conductive to accidents. Convergence means an ability to get the impression of a single object through two images on the retinas of both eyes. Depth Perception or Stereopsis is the impression of depth gained from the fact that both eyes see an object from a slightly different angle. Sudden closure of eye-lids against excessive light is the safety response. Colour vision is due to the ability of the retina to distinguish between light of different wavelengths. It is not equally sensitive to all wave lengths.

But the sight cannot do anything without light. The eye can portray to the brain only such impressions as are carried to it by light waves, and if these light waves are insufficient because of poor illumination, the effect is the defect in performance. Inadequate visual perception is a direct or indirect cause of many accidents. Visual perception depends on many factors which must be studied, to improve them. Some such factors are:

1. The eyesight of a person.
2. The quantity and quality of light on the object to be seen.
3. The size, shape, speed arid distance of the object.
4. The degree of colour contrast between the object and its background.
5. The obstructions, transparent or nontransparent, in the path of the light rays between the eye and the object.
6. Glare and shadow if any.

Thus light, colour, their quantity and quality are the important factors for any visual perception and work performance-depends on it.

2 PURPOSE AND BENEFITS OF GOOD LIGHTING

2.1 Purpose and Advantages of Good lighting:

Purpose, need, advantages or benefits of good lighting are many. There are three groups of working conditions : (1) Physical or environmental i.e. lighting, ventilation, noise, atmospheric conditions etc. (2) Relating to time i.e. hours-of work, rest pauses etc. and (3) Relating to social situation within which an individual works. The lighting influences all the three categories and is an important working condition not only in factories but at all work places. Therefore it should be effective and not poor.

The purpose of light is most important, because without light the things have no appearance, no colour, no shape and no perspective. Light and colour affect human efficiency, accident-possibility and his general well-being, morale and fatigue. Medical research has proved that a sufficient amount of light is needed for the healthy physiological functioning of human organism. Light regulates various physiological functions within the body and poor light adversely affect the health. .

Benefits of good lighting are also direct and manifold, because, it affects our sight as well as the object to be seen. It helps in two ways, by better seeing for work performance and better environment. Better seeing condition causes better discrimination, concentration, alertness and less fatigue. Better discrimination causes less spoilage and quick fault detection. Greater concentration causes better work. Less fatigue allows greater output and greater production. Better environment produces better morale,. comfort, supervision and interest. All these factors cause better ability to perceive objects and keep a clear view of all details, of better conservation of energy and material, reduced labour turnover, better housekeeping, more production with less waste of material, energy and labour, prevention of eye strain and accidents, increased accuracy, efficiency, productivity, speed of seeing and reading and improvement in health and safety of work-people. It is most useful to elderly people.

2.2 Effects of Bad or Poor Lighting:

Effects of bad lighting are direct and manifold, because, it affects our sight or visual perception. Bad light causes glare, shadows, darkness, eye strain, restricted vision, fatigue, headache, slower reaction and greater susceptibility to error and accident and lower output. Accidents during night are obvious due to bad or insufficient lighting. Therefore, need of light is basic and essentially required to work better, to avoid eye strain and to reduce accidents.

Gloomy, dirty and poorly lighted workplaces cause depression. Poor lighting causes great hardship e.g. difficulty in reading micrometer, making fine adjustment, passing a thread in needle and the like. Conversely, well lighted workplace looks delightful and encourages to work.

Poor lighting requires more time to see or distinguish object. Glare and shadows cause eye-strain resulting in more chances of accidents. Therefore to increase safety, prescribed standard of illumination is the basic (minimum) working condition. See part 4 for Standards.

2.3 Increase of Safety arid Productivity due to Good Lighting :

Good lighting includes both, day lighting and artificial lighting and they should be in the requisite proportion. The spectral composition of light and colour layout should be appropriate to gain their maximum advantages.

Good light decreases accident and increases work quality and quantity, productivity and promotes better health and morale of all work-people. In industry, therefore, it is the duty of lighting engineer to consider this basic need and to provide good seeing conditions to,, avoid accidents due to visual disorder. Planning from the design stage will help much.

Good lighting makes the worker more alert and enables him to concentrate and use better discrimination which result in less spoilage, less rejects, fast fault detection, better work and ultimately in Safety.

Numerous studies have shown a close relation between accident frequency and lighting conditions.

An old study by the National Industrial Fatigue Board (USA) indicates that work output (efficiency) decreases because of poor lighting. The change in efficiency as measured by production record and number of errors made because of change in illumination was the subject of numerous studies. Improvements in lighting increase production and decrease errors.

In one case study (Electrical Times of 14-031980), accidents decrease in three companies was 50%, 43% and 52% as an effect of improved illumination.

The Travellers' Insurance Company estimated that of 91000 accidents, 24% were due to imperfect lighting.

One 18-days study showed that the employees with the greatest deviation from the visual standards had the largest accumulation of accidents.

In one factory when illumination was increased from 50 to 200 Lux, the reduction in accident was 32%. Another reduction of. 16.5% was noticed when the walls were treated with high reflectance paint which increased the illumination level to @ 250 Lux.

In a machine tool factory with the rise from 32 to 430 Lux and machines painted to reduce brightness contrasts, the accident rate was decreased up to 50%.

In a textile mill with the prescribed illumination level, a safety award was won for its accident-free performance. This proves that good lighting increases safety.

A few examples from the samd journal are reproduced in Table 9.1 to show such effects.

Table 9.1 : Effect of Light on Work

Type of Work	Illuminance (Lux)		Performance Increase (%))	Rejects Decrease (%)
	Old	New		
Composing room (print)	100	1000	30	18
Cotton Spinning Mill	170	750	10.5	39.6
Wood MFg. Co.	300	2000	16	29
Screw Sorting	100	1000	10	22
Telephone Assembly	150	250	36	57
Tool Co.	500	2000	10	20

The results of a study made by the Research Centre for Lighting Practice, Germany, showed that the increase from 100 to 300 lux raised the productivity by 4% and from 300 to 400 lux raised further increase of 2%.

These results conclude that there are optimum Sighting conditions for each job, the intensity and nature of which can usually be determined through experimentation. A mark increase in intensity in one place may not produce results commensurate with the additional expense. The power necessary should be determined in terms of comfort for the person with normal visual actual acuity and the production records. More luminance level is required after the age of 40.

The specified result improvements (in quantity and quality) were the outcome of the combined effect of the improvement in the primary visual functions (vision acuity, contrast sensitivity, depth and colour distinction etc.) and light dependent increase in psychological and physiological activation.

Emergency lighting should be provided where power failure is frequent and no natural lighting is possible due to absence of windows etc.

3 PRINCIPLES OF ILLUMINATION

3.1 Definitions :

Light is the electromagnetic visible radiation (waves) Within the range of 380 to 760 nanometres (I nm = 10-9 m) or 7.5 x 1014 to 4.3 x 1014 hertz (Hz). The optical spectra, the luminous (electromagnetic) radiation capable of inducing visual sensation through the eye within the range of wavelengths from 10 to 340000 nm, can be divided, depending on wavelengths, into the ultra-violet region (from 10 to 380 nm), the visible region i.e. light (from 380 to 760 nm), and the infrared region (from 760 to 340000 nm). In the visible region, colours from violet (380 nm) to red (760 nm) are recognisably visible. The sensation of colour is also associated with the radiation wavelength.

Luminous radiation exerts certain influence on the nervous system, pulse rate, intensity of certain metabolic reactions and the psychological state of man. For a rational or an adequate lighting, the quantity and quality of illumination, both are essential. Some basic concepts, units and symbols are as follows :

(A) **Luminaire** is a complete lighting unit including the lamp, globe, reflector, refractor, housing and support that is integral with the housing.

(B) **Luminous (or light)** flux is the quantity of light emitted per second by a light source. It is the radiant power or luminous flux i.e. rate of propagation of radiant energy evaluated by the eye. Its unit is lumen (1m) and the symbol F.

(C) **Luminous Intensity** is the luminous flux emitted per unit of solid angle (the measure of spatial density of the light flux) in a given direction. Its unit is candela (cd) and the symbol 1 and 1 = F/w, where w is the solid angle.

(D) **Illuminance or Illumination** is the luminous flux that strikes a unit area i.e. it is the surface (E) density of the light flux distributed uniformly over the surface. Its unit is lux (lx) which is equivalent to 1 $lm/^2$ and the symbol E, E = F/ S, where S is the surface area. When calculating artificial illumination of industrial premises, the concept of mean illuminance usually applies to a horizontal plane 0.8 m above the floor level, also known as the workplace plane.

Old unit of illuminance was foot-candle which is the number of $lumens/ft^2$ or $1m/ft^2$. New unit is lux which is 1 $lm/^2$. Their relation is- .

1 foot candle .= I Im/ft^2 == 10.76 lux (or meter candle or $1m/^2$)
1 meter candle = 1 lux = 0.092 foot candle

Daylight Factor (**DF**) = lux/80

Illuminance level is a prescribed amount Illuminance.

Initial illuminance is the amount of illuminance obtained when the luminaries are neat and clean and when the lamps are first energized.

Service or maintained illuminance is the mean or average illuminance throughout the life of a lighting installation or over an extened period of time. This is lower than the initial illuminance for several reasons stated below.

Light loss factor is a factor which represents the average-to-initial illuminance ratio of a lighting system. It represents the depreciation and deterioration of a lighting system caused by following reasons:

1. Loss of lamp lumens due to aging effect.
2. Decrease in lamp and luminaire output resulting from dust, dirt, insects and chemical changes in the luminaire reflecting surface.
3. Increased absorption of the light output of the luminaries by dust, dirt and chemical changes in the room reflecting surfaces.
4. Differences between actual and design lamp voltages.

Standard illuminance is the service illuminance recommended for standard conditions.

Coefficient of reflection or Reflection factor is the ratio of the light reflected by the body to the incident light. Its symbol is ‘r’.

Coefficient of Utilization, or Utilization factor is the total flux received by a surface divided by the total flux from the lamps illuminating it.

Seeing or visual task is the object being regarded and its background.

Mounting height is the distance from the bottom of the luminaire to the surface used as a reference.

(E) **Luminance (Brightness)** is the luminous flux (directly seen by the eye) reflected by a surface in a given direction. Its unit is candela per sq. m. (cd/m?), and the symbol L. All other conditions being equal, the luminance is proportional to the illuminance i.e. L = lr/s, where r is the reflection factor of the surface, and is given by r = Fref/Ffal where Fref = luminous flux reflected from a surface and Ffal = luminous flux falling on that surface. It is also known as coefficient of reflection.

(F) **Background** is the surrounding surface, real or artificial, against which the object can be visualised or discerned. The background is said to be light if the reflection factor is greater than 0.4, semi-dark, if it is 0.4-0.2 and dark, if less than 0.2. Normal background is the surface behind object.

(G) **Contrast** is the relative luminance between an object and its background (e.g. a letter on paper) and its symbol is C. Where the background has aluminance L and the object a luminance L (L,>L,), it can be expressed C = (L1-L2)/L~. Contrast is a dimensionless magnitude ranging between 0 and 1. It may be high, soft or low.

(B) to (E) are quantitative and (F) & (G) are qualitative indices of illumination.

Digital light meter (photocell device) is available to measure light directly in lux.

For sufficient lighting, lighting level should be measured by lux (light) meter and than it should be compared with the standard lux level given in Part 4.

See Part 6.4 for figure.

3.2 General Principles of Good Lighting:

General Principles or requirements of good lighting are as follows :

1. Adequate illumination.
2. Avoidance of glare.
3. Avoidance of shadow.
4. Uniform lighting.
5. Appropriate contrast.
6. Appropriate colour contrast.
7. Colour effect and
8. Avoidance of flicker and stroboscopic effect.

These are briefly explained below :

See also part 6 for details of design principles

3.2.1. Adequate Illumination :

Adequate, rational or good illumination needs sufficient quantity of illumination necessary for avoiding discomfort to the worker and undue strain on eyes-

The **quantity or intensity of illumination** is given by luminous flux, luminous intensity, illuminance, luminance and reflection factor as explained in the foregoing part 3.1. Its requirement varies from place to place, person to person and with the age of person also. Therefore by experiments, standards of illumination are recommended for a variety of places and jobs to have sufficient quantity of light for better work performance. Such statutory standards and Indian standards are separately given in part 4 of this Chapter.

Visual acuity (sharpness of vision) increases with light intensity and is about equal to daylight acuity as 1000 lux is approached. However, this degree of acuity is seldom required and it is apparent that the desired amount of lighting will vary with the amount of detail required in the work. For example, for very fine work like distinguishing black thread on black cloth, intensity of 2000 lux is required but for exit road, car parking, storage area 20 lux is required.

Although individuals differ in amount of light they find most desirable, 65% of the subjects of one study judged intensity between 10 to 30 foot-candles or 100 to 300 lux, the most comfortable for reading.

The quality of illumination depends on three factors - diffusion, distribution and colour value. Regardless of the quantity of illumination, its effects may be impaired because of the unevenness, the glare or the faulty direction of the light.

Diffusion is the breaking up of a beam of light and the spreading of its rays in many directions by a surface. It is the process of reflection of -light by a reflecting surface or of transmission of light through a translucent material.

Thus adequate illumination requires sufficient quantity and good quality of light necessary for the work.

See Part 3.2.4 for uniform lighting.

3.2.2 Glare :

Glare is the condition in which brightness or the contrast of brightness interferes with vision.

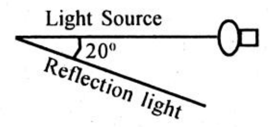
Glare is produced by excessive light stimuli i.e. excessive luminance in the field of vision which disturbs the adaptation process of retina.

Sometimes glare impairs the visual function, of the eye and reduces visual performance.

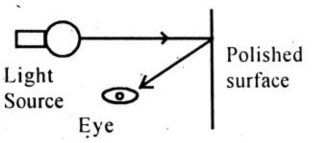
Glare causes discomfort, annoyance, eye fatigue and impairment of or interference with vision. It is produced by excessive light stimuli i.e. too much light which affects the adaptation process of the retina. It can be considered at three levels.(types)- (1) Direct or disability glare (2) Discomfort glare and (3) Indirect or reflected glare.

Direct or disability glare comes directly from the light source to the eye and impairs the ability to see clearly (e.g. dash on upward headlight of a car). This is due to excessive light focused on the eye and scattering of light inside the eye. It depends for its effects upon the position of the light source in the field of view and on the contrast in brightness between the light source and its background. It can be avoided by:

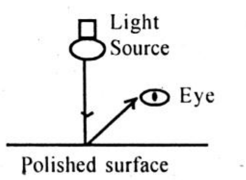
1. Provide diffuser over the lamp or reflector (screen) with minimum reflecting angle 20° below the horizontal, (dipper)



2. Reducing the brightness of the light source (e.g. by enclosing the lamp in bowl reflector).
3. Reducing the area of high brightness (e.g. by installing louvers below the light source).
4. Increasing the angle between the' source of glare and the line of vision i.e. by increasing the mounting height.
5. Decreasing the source of glare so as to lessen the contrast.



Discomfort glare is due to liberal (less) or bright (more) light. It causes visual discomfort without necessarily impairing the ability to see and may occur from unscreened windows in bright sunlight or when over-bright or unshaded lamps in the workroom are too strong in brightness for the workroom environment.

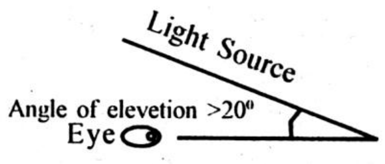


Reflected glare is glare that comes to the eyes as glint (flash) or reflection of the light source from some polished or shining surface. It is caused by a mirror image of the bright light sources reflected from shiny or wet workplaces such as glass or plated metal. These reflections distract or distort attention, make important detail difficult to see and reduce contrast or cause acute discomfort. It can be avoided by:

1. Changing the shining finish by matt finish.
2. Changing the task position or its surrounding.
3. Using light source of low brightness or providing lamp shade.
4. Arranging the geometry of the installation so that there is no glint at the particular viewing direction, e.g. increasing the source height.

5. Providing supplementary lighting.
6. Painting walls and ceiling with light colour so that surrounding becomes bright.
7. Increasing brightness to reduce relative brightness of the glare.

Rule 32 of the Gujarat Factories Rules prescribes, for the purpose of prevention of glare, that where any lighting source is less than 5 mt above floor level, no part of that light having brightness greater than 5 lamberts (1.5 foot candles=16 lux) shall be visible to persons normally working within 30 mt from that source, except where the angle of elevation from the eye to that source exceeds 20°. It is also suggested that local light (lamp on the job) shall be provided with opaque shade or effective screen to prevent glare in the eyes of workers working nearby.



Values of limiting glare index along with average illumination lux value are given in IS:6665 and Appendix D, Part 4 of National Electric Code.

3.2.3 Shadow :

Shadow affects the amount of illumination and is caused not by poor lighting but - by fixing light sources too wide apart or in wrong positions so that light is obstructed by some object. Light (faint) shadow may be allowed but dark (dense) shadow that conceals hazard or indicates wrong thing is not desirable, as it may cause accident.

Shadow on staircase, near door for entry or exit, near tool rack or on the work (job) table is not at all desirable and must be removed by providing extra or local light or shifting the light source or the object causing shadow.

Harsh shadows should be avoided, but some shadow effect may be desirable from the general lighting system to make more noticeable the depth and form o~ object. There are few specific visual tasks where clearly defined shadows improve visibility and such effects should be provided by supplementary lighting equipment arranged for the particular task.

3.2.4 Uniform Lighting :

The human eye can clearly perceive differences in luminance of over 50%. It takes time to adopt sudden variation in the intensity of lighting, particularly from higher to lower intensity. Uniform distribution of lighting is desirable. Distribution of light requires two problems to solve (1) uniformity of illummation and (2) elimination of shadows.

In uniform lighting, the distribution of light with a maximum and minimum illumination at any point should not be more than one-sixth above or below the average level in the area. Indirect lighting is the best method for producing uniform illummation. Here all the usable light is reflected light, high points of light from the bulb striking the eye directly are out of the visual field. The disadvantage of indirect light is its cost, since considerable light is lost through absorption. However its benefit is more worth than its extra cost.

3.2.5 Contrast:

The ability to see detail depends upon the contrast between the detail and its background. The greater the contrast, difference in luminance, the more readily the seeing task is performed. The eyes function most comfortably and efficiently when the luminance within the remainder of the environment is relatively uniform. Therefore all luminance in the field of view should be carefully controlled. 15:3646 (Part I & II) provide details for this. Reflectance should be maintained as near as practical to recommended values (For ceiling 80 to 90%, for walls 40 to 60%, for desks and bench tops, machine and equipment 25 to 45% and for floors not less than 20%). High reflectance surfaces are desirable to provide the recommended luminance relationship and high utilisation of light. They improve the appearance of the work place. It is also desirable that the background should be slightly darker or paler than the seeing task. Too much contrast is not desirable.

The contrast recognises the object easily and increases visual performance. If the difference between the object (job or seeing task) and its background is not noticeable, it is difficult to work. A black machine in black background (darkness) is difficult to notice. There should be a minimum contrast between the visual target detail and its background.

The differences in luminance of visual task, its immediate background and environment should not exceed certain maximum values i.e. a relationship of 10: 3:1 for normal tasks and 10 : 5 : I and 10 : 10 : I for precision work.

3.2.6 Colour Contrast:

Eye sees an object by the light it reflects and distinguishes its details mainly by colour contrast. Thus, in addition to luminance contrast, colour contrast may be influenced by the choice of the colour of light. The choice of the correct colour of light depends on the task to be performed and the requirements to be met by vision. It may be noted that there must not only be adequate illumination to see an object clearly, but also the object must be visible in its surroundings. It must have moderate colour contrast. The colour approximating to white will give better colour rendering and light yield. The colour approximating to red will give low Quality colour rendering but the light will create an emotional atmosphere.

A well painted machine inspires a feeling of personal pride and proper maintenance is encouraged.

3.2.7 Colour Effect:

It refers to the appearance of coloured objects when illuminated by a particular light source. It is the property of light which facilitates the perception of surface colours and depends on the spectral composition of the light. For example, red surface will appear red only, if the light falling on it contains red, but it will appear brown under the yellow of sodium street lighting.

The maximum value of the index is 100 and at this value there is no shift, i.e. the colour rendering is perfect. For example, an incandescent tungsten filament lamp has a colour rendering index of 100, fluorescent tubes between 55 to 95, mercury vapour lamps approximately 45 and low-pressure sodium vapour lamps less than 25. Where colour discrimination and colour matching are a part of the work process, the light source selected should have the desired colour rendering properties. .

3.2.8 Flicker and Stroboscopic Effect :

All lamps working on alternating current give light which pulsates at twice the supply frequency. This type of discontinuous light of almost all frequencies can produce (fleshing rapidly to show moving object stationary) effect, in which a rotating or reciprocating object can appear to be stationary, or moving slowly, or even appear to be rotating in the opposite direction etc. This false belief can cause accidents in the industrial situation. It is a real hazard in the presence of moving machinery. High intensity discharge lamps and fluorescent tubes have some 'flicker content in their light output at twice the mains frequency. The steps to diminish the stroboscopic effect are:

1. Light the moving object with lamps fed from two different out of phase a.c. supplies, or from two or three phases of a three-phase supply or lead lag luminaries.

2. Select a lamp with a low flicker characteristic, e.g. a fluorescent coated high-intensity discharge tungsten filament (GLS) lamp or ordinary filament lamp.

3. Add a local GLS lamp to augment the general lighting.

4. Use GLS or tungsten halogen lamps fed from a direct current (d.c.) supply.

5. Use the common twin-tube circuit.

4 RECOMMENDED STANDARDS OF ILLUMINATION

It is not a simple matter to specify suitable intensity levels based upon sound reasoning. As there is no fixed threshold level of illumination below which a visual task is greatly impeded, some compromise has to be made between an ideal level and adequate level. Generally a recommended level is arrived at after careful consideration of eyesight, the visual task, the environment and the economy involved. Any specification is therefore, opens to controversy, the recommended level, however, serves chiefly as a guide to good practices. Standard illumination benefits people with normal sight and helps to faulty vision. It can be achieved through a combined usage of day lighting and artificial lighting and maintained by proper cleaning and re-lamping etc.

Importance of illumination level:

Illumination, noise, temperature and other environmental conditions such as chemical exposure and vibration play an important role in the ability of humans to interact effectively with equipment or a system.

Lighting is an important element in the design of any system as improper lighting levels may cause system elements to be seen incorrectly or not seen at all. Improper-illumination level may result in the eye strain, muscle fatigue, headache or accidents.

The adequacy of lighting depends upon the type of lighting provided, its quality and quantity, the age of the worker and visual requirements of the task or system.

Illuminance ranges

Circumstances may be significantly different for difficult interiors used for the same application or different conditions for the same kind of activity. A range of illuminance is recommended for each type of interior or activity. Each range consists of three successive steps of the recommended scale of illuminance. Middle value of each range, represents the recommended service illuminance that would be used unless one or more of the factors mentioned below apply.

Higher value of the range should be used when:

1. Unusually low reflectance or contrasts are present in the task.
2. Errors are costly to rectify.
3. Visual work is critical.

4. Accuracy or higher productivity is of great importance.
5. The visual capacity of the worker makes it necessary.

The lower value of the range should be used when:

1. Reflectance or contrasts are unusually high.
2. Speed and accuracy is not important.
3. The task is executed only occasionally.

Depending upon importance of the work, illumination level must be according to the standards mentioned below.

4.1 Statutory Provisions :

Section-17 of the Factories Act requires sufficient and suitable lighting, natural, artificial or both and prevention of direct or reflected glare and shadows causing eye strain or risk of accident.

Rules 30 to 34 of the Gujarat Factories Rules prescribe further details. General level of 30 meters candles (30 lux) or more at the horizontal level of 91.4 cm (3 feet) above the floor is prescribed. Where the light source is above 7.6 meter height from the floor, at least 10 meters candle minimum illumination should be available. It should be at least 30 meters-candles (30 lux) where the work is actually going on. Walkways require at least 5 meter candles (5 lux) at floor level. Rule 32 describes details to prevent glare, (see Part 3.2.2)

Minimum illumination levels prescribed by **Rule** 35 of the Maharashtra Factories Rules is given in Table 9.2

Table 9.2 : Minimum Illumination Levels u/r 35 MFR

S. No.	Area / Workroom	Minimum Intensity of Illumination in Lux
1	Stock-yards : main entrance and exit roads, cat-walks of outdoor plants, coal unloading and storage areas.	20
2	Passage-ways, corridors and stairways, warehouses, stock' rooms for large & bulky materials, platforms of outdoor plants, basements.	50
3	Engine and boiler rooms, passengers and freight elevators, conveyor crating & boxing departments, storerooms for medium and fine materials, locker rooms, toilet and wash-rooms.	100
4	Where discrimination of detail is not essential (e.g. handling of material of coarse nature, rough sorting, handling coal or ashes etc.)	50
5	Where slight discrimination of detail is essential [e.g. production of semi-finished iron and steel products, rough ; assembling, opening, carding drawing, spinning (ordinary) counts of cotton].	100
6	Where moderate discrimination of details is essential (e.g. medium assembling, rough bench work and machine work, inspection and testing of products, canning, sawing, sewing of light coloured textiles and leather products, weaving light	200

	thread, warping, spinning fine counts).	
7	Where close discrimination of S detail is essential (e.g. medium bench and machine work, fine testing, .flour grading, leather finishing, weaving cotton goods or light coloured woollen goods, welding sub-assembly, drilling, rivetting, book-binding and folding).	300
8	Where discrimination of fine detail is involved under a fair degree of contrast for long periods of time (e.g. fine assembling, fine bench and machine work, fine inspection, fine polishing and bevelling of glass, fine wood working, weaving dark coloured woollen goods).	500
9	Where discrimination of extremely fine detail is involved under conditions of extremely poor contrast for long periods of time. (e.g. extra fine assembling, extra fine inspection, jewellery and watch manufacturing, grading and working of tobacco products, dark cloth hand tailoring, final perching in dye works, make-up and proof-reading in printing plants).	1000

4.2 Indian Standards :

SP 32 a Handbook on functional requirements of industrial buildings (lighting & ventilation) may be referred.

Some useful IS are given in Table 9.3 : Table 9.3 : Indian Standards on Lighting

S. No.	Area / Workroom	Minimum Intensity of Illumination in Lux
1	Industrial lighting	6665
2	Day lighting of factory buildings	6060
3	Day lighting of buildings	2440
4	Principles of good lighting and aspects of design (Part I)	3646
5	Schedule for values of illumination and glare index (Part II)	3646
6	Calculation of coefficient of utilization by the BZ method (Part III)	3646
7	Eletro technical vocabulary Part 16	1885
8	Flameproof electric lighting fittings	2206
9	Dust – proof electric lighting fittings	4012
10	Dust-tight electric lighting fittings	4013
11	Miners' Cap-lamps	2596

Out of 63 types of industrial buildings and processes, only 15 are selected from Table-2 of 15:6665 and given in Table 9.4 as a sample recommendation.

Table 9.4 : Recommended Values of Illumination (IS : 6665)

S. No.	Industrial buildings and processes		Average Illumination Lux
1	**General Factory Areas:**		
	a	Canteens	150
	b	Cloakrooms, Entrances, Corridors & Stairs	100
2	**Factory Outdoor Areas:**		

	Stockyards, main entrances, exit roads, car parking, internal factory roads		20
3	**Assembly Shops:**		
	a	Rough, work, for example, frame assembly, assembly of heavy machinery	150
	b	Medium work, for example, machined-part, engine assembly, vehicle body assembly	300
	c	Fine work, for example, radio and telephone equipment, typewriter and office machinery assembly.	700
	d	Very fine work, for example/assembly of very small precision mechanism, instruments	1500
4	**Boot and Shoe Factories :**		
	A	Sorting and grading, Cutting table and presses stitching	1000
	B	Clicking and closing, preparatory operations, bottom stock preparation, lasting and bottoming, finishing and shoe rooms	700
5	**Canning and Preserving Factories :**		
	a	Inspection of beans, rice, barley etc.	450
	b	Preparation : kettle areas, mechanical cleaning, dicing, trimming, high speed labelling lines	300
	c	Cam-led and bottled goods :Rotors.	200
	d	Can inspection	450
6	**Chemical Works:**		
	a	Hand furnaces, boiling tanks, stationery dryers, stationery crystallisers, dryers, filtration inechanical bleaching, percolators, or gravity mechanical evaporators, plants, crystallising, extractors, nitrators, electrolytic cells.	150
	b	Controls, gauges, valves, etc.	100
	c	Control rooms: Vertical control panels & Control desks	200 to 300
7		**Die Sinking :**	
	a	General	300
	b	Fine	1000
8		**Engraving :**	
	a	Hand	1000
	b	Machine (see Die Sinking)	-
9		**Foundaries**	
	a	Charging floors, tumbling, cleaning, pouring, shaking out, rough moulding and rough core making.	150
	b	Fine moulding and making inspection.	300
10		**Inspection Shops (Engineering):**	
	a	Rough work, for example, counting, rough checking of stock parts etc.	150
	b	Medium work, for example, 'Go' and 'No-Go' gauges, sub-assemblies.	300
	c	Fine work, for example, radio and telecommunication equipment, calibrated scales, precision mechanisms, instruments.	700
	d	Very fine work, for example, gauging and inspection	1500

		of small intricate parts.	
	e	Minute work for example, very small- instruments	3000
11		**Iron and Steel Works :**	
	a	Marshalling and outdoor stockyards	10 to 20
	b	Stairs, gangways, basements, quarries, loading docks, slab yards, melting shops, ingot stripping pits, blast furnace working areas, picking and cleaning lines mechanical plants, pump houses.	100
	c	Mould preparation, rolling and wise mills, mill motor rooms, power and blower houses.	150
	d	Slab inspection and conditioning, cold strip mills, sheet and plate finishing, tinning, galvanizing, machine and roll shops.	200
	e	Plate inspection	300
	f	Tinplate inspection	Special Lighting
12		**Laboratories and Test Rooms :**	
	a	General laboratories, balance rooms	300
	b	Electrical and instrument laboratories	450
13		**Machine and Fitting Shops :**	
	a	Rough bench and machine work.	150
	b	Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing.	300
	c	Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing.	700
14		**Paint shops and Spraying Booths :**	
	a	Dipping, firing, rough spraying.	150
	b	Rubbing, ordinary painting, spraying and finishing.	300
	c	Fine painting, spraying and finishing.	450
	d	Retouching and matching.	700
15		**Sheet Metal Works :**	
	a	Benchwork, scribing, pressing, punching, shearing, stamping, spinning, folding.	200
	b	Sheet inspection.	Special Lighting

4.3 ILO Recommendation:

As given by ILO Encyclopaedia of Occupational Health and Safety, some recommended illuminance are given in Table 9.5.

Table 9.5 : ILO Recommendation

Class of Visual Task	Typical Examples	Recommended Illuminance (Lux)
1. Exceptionally difficult tasks	Inspection of minute work, jewellery, watch-making, hosiery, knitwear.	2400 or more
b. Very difficult	Extra-fine bench and machine work, tool & die making examining of dark goods, dye works - final perching.	1600
	Clothing trade-inspection, hand tailoring, grading	1200

	and matching dark leather, dye-works-colour matching.	
3. Difficult	Fine bench and machine work, extra fine painting, spraying, matching, dye works-reception, grey perching.	800
4. Normal range of task and work-places	Office work with poor contrast, drawing office, fine painting, proof-reading, computer rooms.	600
5. Moderately difficult	Medium bench and machine work, typing, filing, reading, writing, wood working, steel fabrication.	400
6. Ordinary	Chalkboards & charts, pharma-stores, bottling & canning plants, book binding, food preparation, cooking, canteens	300
7. Simple	Rough bench and machine work, counting, checking, halls, waiting rooms, warehouses, stores, parking, dispatch.	200
8. Rough intermittent tasks	Live storage, rough bulky material, loading bays, change / locker rooms.	100
9. Movement & Orientation.	Corridors with heavy traffic, walkways, stairs, rest-rooms, lanes.	50
	Corridors with light traffic	20

5 TYPES OF LIGHT, SOURCES, FITTINGS AND INSTALLATIONS

5.1 Types of Light (Lighting) :

Day lighting and artificial lighting are the main types. Other classification is minor. Most people prefer to work in day-light i.e. natural or general light. However in a large shed or for work indoors, natural light is not fully available in whole area and for the whole working day. In that case, it needs to be supplemented by an artificial or electric lighting. Automatic or manual control systems are available to vary the output of electric lighting necessary to complement the daylight and maintain the recommended (set) level.

Lighting is also classified as general, supplementary, direct, semi-direct, indirect, semiindirect, diffused etc. depending upon its nature, reflection or way of utility.

General lighting is that quantity and quality of day lighting which alone provides the recommended standard of illumination.

Supplementary lighting is that additional artificial (electric) lighting needed to meet the required standard or particular demand of any job. For this purpose supplementary luminaries are used to provide higher illumination levels for small or restricted areas. Also they. are used to furnish a certain luminance,

colour or to permit special aiming or positioning of light sources to produce or avoid highlights or shadows to best portray the details of the task. At the dark spots, supplementary lighting is required. Permanent supplementary artificial lighting (PSAL) in buildings is required where adequate day lighting over tile whole working area is not available and to create acceptable brightness levels on the various surfaces in working interior.

Diffused or reduced light through some surface should be sufficient otherwise it may cause discomfort or eye-fatigue.

Security or Protective Lighting is required in bordering areas and security points for night-time policing. It will show and restrict entry of intruders. It is of four types - floodlights, street lights, fresnel lens units and searchlights. It may be required at the time of evacuation of people in case of emergency. Alternate power source (e.g. DG set) should be connected to emergency or protective lighting.

Floodlights provide area lighting at an economical cost. They must be located at suitable mounting heights and with unobstructed beam paths. Mounting can be on pipe or pole, platforms, rigging structures etc. Floodlights are of lamp types and with beam spreads from 10 to 18 degrees.

For direct, indirect and semi direct/indirect lighting see part 5.1.3.

5.1.1 Day, Natural or General Lighting:

In our country natural sun light available during most of the days is called daylight or day lighting. Its varying intensity from sunrise to sunset provides harmonious variation of the visual environment inside or outside a building and is normally welcomed for the visual task. It is the cheapest light and should be effectively utilised by proper design of roof, doors, windows and ventilators. Generally northlight roof, also known as saw toothed roof or pent roof, is a more efficient way of getting daylight without glare and heating by direct sunlight. The standard size windows should be provided on both sides opposite to each other to obtain better and uniform illumination throughout the area. It provides cross-ventilation also.

Windows, monitor (louvers) roof and the north light roof are generally preferred for day lighting. In our country mostly north-light (saw tooth type) roofs are preferred in the northern hemisphere. Such design keeps off direct mid-day sun in latitudes north of 23". Transparent high density plastic or FRP sheet (plain or corrugated) is provided, in roof at certain intervals. Transmission coefficients of some such materials are given in Table 9.6.

Table 9.6 : Transmission Coefficients (for visible light) for some glazing materials (IS : 6060)

	Material	**Trans. Coeff.**
1	Transparent window glass	0.80 to 0.85
2	Clean acrylic plastic sheet	0.85 to 0.80
3	Patterned glass	0.70 to 0.85
4	Clear rigid PVC	0.80
5	Wired rigid PVC	0.75 to 0.70
6	Sand blasted glass	0.80 to 0.65
7	Wired finish glass	0.80 to 0.60
8	Corrugated glass fibre reinforced sheet	0.80 to 0.55

Proper, utilisation of day lighting to get appropriate illumination levels on the working plane in factories will result in considerable economy consistent with efficiency of production and worker's well-being. The Central Building Research Institute, Roorkee carried out research and measurements of daylight requirements for factory building and IS:6060 is prepared on the basis of its investigations.

One research has shown that artificial lighting in the absence of natural (day) light, affects the autonomous nervous system. Therefore artificial (electric) lighting should be controlled in accordance with the variations of daylight.

See also Part 6.2.

5.1.2 Artificial Lighting:

During night time i.e. in the absence of daylight, artificial light is the only remedy. Even during day time where the day lighting is insufficient to provide prescribed illumination due to any obstruction or weather effect, it will be necessary to supplement the natural lighting by artificial lighting designed to operate permanently during day time. It should be properly co-ordinated with natural lighting as per 15:3646 (Part 1). The combination of day lighting and artificial lighting is known as twilighting.

Types of artificial light depend on types of artificial (viz electrical) light sources or their fixtures. Lighting from electric lamp or tube or from many types of their combination gives a verity of artificial lighting. For detail see Part 5.2 and 5.3.

See Part 6.3 for installation of artificial lighting.

5.1.3 Direct and Indirect Lighting

Direct Lighting means light falling on object directly from source - natural or artificial. Thus direct light from Sun or electric tube on the job or book is called direct lighting. Its first reflection is to the eye, therefore, it should not be excessive, otherwise it may cause reflected glare or eye strain. Local light (lamp) hanging on machine is a direct light. Direct artificial light requires less electric power consumption than the indirect artificial light for the same brightness required.

Indirect lighting is reflected or diffused light coming after reflection of light from some surface or coining through some transparent surface. Its benefit is to avoid direct glare and to make the light of comfortable brightness.

Semi-direct or semi indirect light is a combination of direct and indirect light. Direct light from window and simultaneously reflected light form a lamp is of this type of light. Where direct or indirect light, is insufficient, lighting level is increased by this type of combination.

5.2 Types of Light Sources:

It is interesting to note that electric lamps produce more heat than light as follows:

Type of Lamp	Heat (%)	Light (%)
Incandescent	97	3
Fluorescent	90	10
Sodium Vapour	80	20

Other types and lamp data are given in Table 9.7.

Table 9.7:. Lamp Data

Type of Lamp	Luminous Efficiency lumens / watt	Bulb life Hours	Colour Rendering Index
Incandescent GLS or PAR Tungsten-filament	12-22 10-13 13-18	1000 10000	100 50-69
Tungsten-halogen (T-H)	20-27 14-22	2000	70-84
Fluorescent Tube White Tubes	75-95 50 62-66	5000 5000	55-75 85-95 56

Triphosphor	69-70	7500	85
Mercury Vapour Lamps High Pressure (HPMV) with fluorescence MBI	55 35-50 63-72	3000 5000 6000 7500	25 45 70-84
Sodium Vapour Lamps Low Pressure (SOX) High Pressure	110-140 95	4000 8000	20 45
Metal halide lamps	75-125	3000 to 20,000	

Apart from above factors, the selection of light source also depends on -

1. Type of application.
2. Atmospheric conditions of industrial interiors and/or exteriors.
3. Surface features.
4. Initial outlay.
5. Running cost.
6. Ease of maintenance.

Types of lamps are:

Incandescent filament lamps including tungsten and halogen are simple, compact, versatile and suitable where artificial lighting is occasionally required, space is restricted and a powerful concentrated beam of light is required. Short life and low efficiency are their disadvantages.

Halogen lamps are mainly used for terrain lighting and as automobile head (driving) lights.

Fluorescent lamps or tubes are good for medium height ceilings and general uniform lighting whereas for highways HPMV lamps or their combination with tungsten filament lamps are used. Generally fluorescent tubes are preferred because of their higher efficiency, long life, low brightness, minimum glare and shadows, colour rendering close to daylight, less heat and linear form. They are mostly required for regular artificial light, good colour rendering effect and increasing illumination level.

Mercury vapour lamps, colour corrected, are more suitable and economical in a large, lofty building (viz. steelworks) having high height and also for exterior lighting of storage areas, clocks, roadways etc. If colour rendering is not important, ordinary uncorrected mercury lamps may be used.

Sodium vapour lamps are seldom suitable for interior lighting due to their poor colour rendering properties. Low-pressure sodium lamps are used for terrain and road lighting and also in high halls where colour rendering is not demanded. High pressure sodium lamps are also developed to improve colour rendering.

High-pressure sodium lamps have efficacies that range from 77 lumens per watt to 140 lumens per watt, depending on size. The colour rendition is a distinct orange. Warm-up time for high-pressure sodium lamps is from 3 minutes to 4 minutes. Restrike time is less than I minute, and instant restrike devices are offered for 50-watt to ISO-watt high-pressure sodium lamps. Power factors range from 40 percent to 99 percent depending on the heavy type and the age of the lamp. Lamp life is 24,000 hours.

Metal halide lamps are similar in construction to mercury vapour lamps. The difference is that metal halides are added to the mercury and argon in the arc tube. The efficacies are improved to the range of 75 lumens per watt to 125 lumens per watt, excluding ballast loss. The colour rendering is quite white and is usually superior to the phosphor-coated mercury vapour lamp. The warm-up time for metal halide lamps is 2 minutes to 4 minutes, and re-strike time varies from 5 minutes to 15 minutes, depending on the type. Power factors in the range of 90 percent can be obtained. Lamp life varies from 3000 hours to 20,000 hours. Metal halide lamps have more rapid lumen depreciation than do mercury vapour lamps and have high surface operating temperature which must be. considered before application in classified locations. The lamp life and lumen output are affected by burning position.

Compared with incandescent lamps, mercury vapour lamps offer the advantages of longer average life and higher lumen output; however, with the advent of metal halide and high pressure sodium lamps, the mercury vapour lamp is considered by many to be obsolete, except in existing plants .having similar lamps. The mercury vapour lamp is considered obsolete because of its rapid lumen depreciation and low lumens-per-watt characteristics.

Mercury vapour, or mercury-halide lamps, tubular fluorescent and sodium vapour lamps are generally called 'electric discharge lamps' as electric current is passed through certain gases to produce emission of light.

From above types the mercury vapour lamps take up to 6 minutes and sodium vapour lamps take up to 20 minutes to reach their maximum output, the actual time will be determined by the wattage of the lamps. In the event of a power failure, restoration of power will immediately start machinery, while discharge lamps would take 'warming time' to relight. This time gap may cause accident due to insufficient lighting. To avoid such situation emergency lighting is a must which will glow during power absence.

Selection of the type of light source depends on efficiency, installation, running costs, maintenance, life characteristics, size, robustness and heat & colour output. The efficiency of any lamp is the light output per unit of electricity consumed and is measured in lumens per watt. For example, it is as under:

Type of Lamp	Lumnes per watt (approx.)
Incandescent lamps	15
Tungsten halogen	22
High pressure mercury	35-55
Fluorescent lamps	75-95
High pressure sodium	100

Incandescent lamps are cheaper but they are more expensive than other types of lamps to run and they require frequent replacement. Discharge and fluorescent lamps cost more to install but their greater efficiencies and longer life make them more suitable for general interior lighting.

Where colour performance is important, the tubular fluorescent lamp is more suitable and not the mercury or sodium vapour lamp. Where lighting is required at height (e.g. overhead crane in workshop) the high pressure discharge lamps are more suitable.

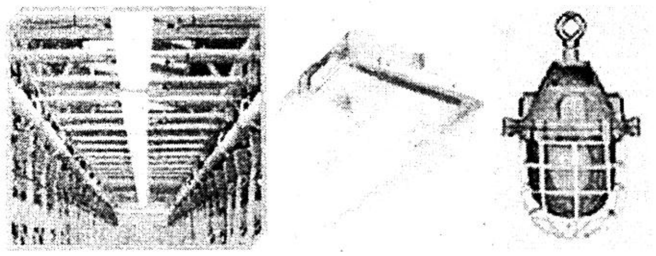
Where artificial lighting is supplied, hazards of electricity must be identified and removed. Loose wiring, faulty switches or fuses, un-insulated wire or cable, open switch box, open wire in plug, many joints in phase wire etc. arc sources of danger with electric lighting. Safe lighting is low voltage lighting (allowing low current at the same resistance E = IR) -or solar lighting-

Similar precautions are also necessary while providing lighting in hazardous areas. Dust, dampness, flammable/explosive atmosphere, corrosion etc. require standard flameproof electric lighting. Electric equipment/tool should also be of the approved type. See Chapter-11 for details.

5.3 Types of Lighting Fittings:

Luminairc is a general term used for all the apparatus necessary to provide a lighting effect. It includes all components for the mounting and protection of lamps and connecting them to power supply i.e. the whole lighting fitting.

In selection of a luminaire (lighting fitting), a separate study should be made for each application. Factors influencing the selection are appearance, efficiency, glare, density of equipment, frequency of operation, maintenance, required colour rendition and hazardous area classification.



The lighting fillings or fixtures are of many types, viz. bare, reflector type (direct), direct-indirect, louvered diffused, diffused panels, local lighting units, hand lamps and flame proof and dust proof fittings for hazardous areas. Hand lamps should be of low voltage = 24 V and flameproof if it is to be used in flammable area. It should have a lamp guard and an insulated (non conductive) handle. Some typical general lighting units are as follows:

1. **Industrial type troughs and shades:** These have small slots which allow at least 10-15% of the light to escape in an upward direction. This will be sufficient to dispel overhead gloom and also ensure adequate ventilation of the fitting, thus helping to prevent dirt from collecting inside.

2. **Totally-enclosed diffusing units :** Units of this type provide high quality lighting and the incandescent varieties are by far the best type to use when an office is to be lit with incandescent lamps. The fluorescent version gives comparatively little upward' light and for this reason it should be ceiling-mounted rather than suspended.

3. **Louvers fluorescent units :** These may have metal louvers, or translucent diffusing ones. If suspended from the ceiling, at least some of the lamps should emit unobstructed upward light. Such units are generally less affected by airborne dirt than totally enclosed types.

4. **Direct-Indirect units :** The essential features of this type of unit is the pair of large apparatus (some 2 or 3 inches wide) above the lamps. These large slots allow some 40% of the available light .to escape to the ceiling and for this reason it is convenient to refer them as "40/ 60" fittings (this being the relative proportions of upward and downward light). Being made entirely of metal, such fittings are frequently cheaper than the enclosed diffusing type.

5. **Bare fluorescent lamp units :** If the room is very small (so that all lamps are well up out of the field of view of the occupants) they can be safely used. They can also be sometimes employed in long narrow room where everyone views the units more or less on end.

6. **Recessed units :** In offices with low ceilings, it is often necessary to recess the lighting fittings, leaving the mouth flush with the ceiling. In such cases light from the fittings can only reach the ceiling by reflection and the system is most likely to be satisfactory when the room is small in. size, with a light decoration scheme or when the general illumination is reasonably high (at least 50 lm/sq. ft or 500 lux).

7. **Luminous and louvered ceilings :** In general, a louvered ceiling gives better visual conditions than a luminous ceiling made of continuous sheets of diffusing material. A uniformly bright luminous ceiling tends to produce excessively diffused lighting which is apt to make the interior look dull unless the illumination level is particularly high.

8. **Incandescent lamp units:** Deep shades should be used and a black band should preferably be painted round the inner edge of adjustable shades which may be set at an angle.

Hand lamps should be of a well designed, strongly constructed type. The lamp socket should be properly shrouded and insulated from the wire guard. Low-voltage incandescent lamps are more efficient and robust than equivalent mains voltage types. They are safer to use, provided that the supply transformer is properly insulated and earthed, preferably at the centre point of the secondary winding. In particularly dangerous situations (e.g. inside a metal tank or boiler shell) the lamp voltage should preferably be below 24 volts, with centre-point earthing to reduce the maximum potential to earth to 12 volts.

9. **Fluorescent lamp units:** Troughs should be mounted either low enough to ensure, that all bright surfaces are completely hidden, or high enough to ensure that they are well outside the normal field of view.

5.4 Types of Lighting Installations:

The term lighting installation includes types of lighting, light sources and fittings just mentioned in foregoing parts 5.1 to 5.3. It is a broad term describing overall artificial lighting arrangement.

Generally lighting installation is classified as :

1. Uniform general lighting.
2. General plus local supplementary lighting.
3. Localised general lighting and
4. Special purpose lighting (ultraviolet lamp etc.).

Uniform general lighting should be (1) as high as possible to avoid glare (2) spaced evenly proportional to mounting height and(3) uniform and not less than 2/3 of average anywhere. If mounting height is H, then distances of spacing of rows, close to wall and gangway along a wall should be 1.5 H, 0.5 H and 0.75 H respectively. Uniform general lighting is suitable in place where the work points are not fixed e.g. foundries, large assembly shops, warehouses etc.

In general plus local supplementary lighting, additional local units (usually mounted close to the work point) supplement the evenly distributed general lighting provided by overhead units. The system is required at a few definite scattered locations and where light from overhead installation cannot reach the work point e.g. inside the throat of a heavy power press, inside hopper on point of operation etc.

Generally die average illumination should not be less than the square root of the illumination on the locally lit task.

Locally general lighting is provided by overhead units on individual work benches or machines requiring strong illumination. Desks tables or machines should be lighted from side rather than from directly in front.

5.5 Cost of Lighting :

Old data of cost of lighting, in 1965-66, in 24 German factories was 2% of the wage bill. It was 1.4% UI 10 British factories. It may be assumed around 1.5% of the wage bill of a factory. Lighting cost is the sum of...

1. Cost of fittings x depreciation (@ 10%).
2. Cost of lamps/tubes.
3. Cost of electricity.
4. Maintenance cost.
5. Installation cost = 3 to 6% of the total electrical installation cost (with 10% depreciation cost).

This gives a rough estimate. More correct method incorporating new (latest) factors should be considered.

Economic Effect

1. High level of lighting increases overall costs but out-weighted by increased productivity and lower accident rate.
2. Lower standard of lighting can be accepted when specified, depending on the importance of Area.
3. Overall cost can be reduced by using lamps having a high luminous efficacy and suitable light distribution.

6 DESIGN OF LIGHTING INSATALLATION

Eight points discussed m foregoing part 3.2 are most important to design effective lighting installations. Particularly principles of illumination and utility of types of light, sources and fittings must always be considered while designing factory building and interior/exterior lighting arrangement. Selection of lighting fittings should consider

1. Luminance or brightness.
2. Design of luminaries (1) to avoid glare and shadow under normal seeing conditions (2) to produce highest initial and sustained light outputs.
3. Mechanical construction which can be conveniently installed and repaired.
4. Suitability for normal use and special areas like indoor or outdoor and hazardous (classified) areas.
5. Direction of incidence of light and shadow effect.
6. Colour appearance and colour rendering.
7. Its contrast with the background.
8. The duration of the visual work.

The quality requirements of the lighting increase with difficulty of the visual task. The light distribution of fittings should be as uniform as possible so as to avoid difference in brightness that would be disturbed because continuous / constant change in adaptation of the eye causes premature fatigue. Therefore overall illumination must be as constant as possible.

Normally five types of systems are available direct, semi direct, general diffuse, semi-indirect and indirect. Choice should be as per requirement and may be mixed.

6.1 General Considerations :

These are :

1. Make the task easy to see by providing sufficient light on the work. Troublesome reflections must be avoided.
2. Provide comfortable seeing conditions by eliminating glare, gloom and unwanted shadows. Use well designed lighting fitting with correct spacing and placing. Use suitable light reflecting colours.
3. Keep the installation in. good working order by providing safe and easy means of access, service and maintenance.
4. Select the best illumination level by considering the recommended standards. To assess this need of light consider: (a) quality of eye as an optical instrument (b) level of illumination (c) size, type and speed of the object and work (d) contrast between the object and its background (e) colour contrast (f) available perception time and (g) problem of glare and shadows.
5. Cost of lighting should not result in such an economy to raise indirect cost due to discomfort, damage and accidents.
6. Select flameproof/dustproof and non-corrosive light fitting where they are specifically needed.
7. Pay more attention on inspection areas requiring continuous close observation.
8. Select good lighting for building sites and internal roadways. Use of tungsten halogen floodlights, because of their small size and low cost, permits a temporary installation to be made quickly and easily.

For good design, it is important to seek cooperation between architect, occupational hygienist and lighting engineer to avoid errors from beginning. From the design stage, the planning should include appropriate light distribution and colour layout of the work areas and for that purpose-the type of lamps, luminance distribution, luminous efficiency and spectral composition of light should be considered.

Lighting installations should be designed to meet the conditions peculiar to the tasks of each area. Standard (recommended) illumination levels serve only as a guide to good lighting practice. Obviously depending on work required, illumination should be increased on the task.

6.2 Day lighting of Factory Buildings:

Some design principles are :

1. The design of openings, glazing and similar sources of daylight should be so positioned as to give illumination levels given in Table-1 of IS:6060. The value of sun (sky) light is @ 16000 lux.
2. Usually north lights are employed to provide requisite illtlmination on the working plane. Location of work should be such as to avoid glare from the north light glazed openings.
3. Where work is carried out during dark evening or morning hours, the day lighting should be combined with artificial lighting in such a manner that the reduction of daylight is unnoticeable specially for those engaged in precision work involving eye strain.
4. A careful interpretation of daylight factor (divide lux value by 80 to get daylight factor - DF) should be made before designing the fenestration. Normally factories should be designed to give atleast 1.25 DF.

5. Obstructions like structural members, overhead installations, vertical and horizontal machines and the like should be considered in relation to the glazing. It is essential to foresee the proposed layout orf the machines, as ignorance of this aspect is likely to cut down the light reaching the work plane.
6. There should be a good distribution of light over the whole interior. Lighting affecting one person or one group should be avoided. Light colours should be preferred on the interior surfaces". In case of north light roof truss, shadows caused at working planes by machines and operators can be minimised by providing openings in the side walls and/or by use of light coloured finish for ceiling surfaces.
7. Work should be so located as to avoid glare from the north light glazed openings.
8. The uniformity of illumination on the working plane in a north light factory depends on the width of the bay (distance between the north light openings), the slope of the roof and the reflectance of the ceiling.
9. Other types of north lights such as sawtooth, cylindrical shell or folded plate north light roofs should be designed properly.
10. Side-lighting is similar to vertical windows. Methods given in IS:2440 should be followed. The same IS also suggests the design time for horizontal or inclined roof lighting. Diffusing glasses can be used to diffuse the combined illumination due to sun and the sky light.

6.3 Installation for Artificial Lighting:

Foregoing parts 5.1.2 and 3 to 6.2 must be considered while designing for artificial lighting. As daylight is varying according to day hours, distances and weather effects, design of supplementary artificial lighting should be made from the initial planning. Some factors of consideration are :

1. Determine the quantity and quality of illumination desirable for the work.
2. Based on that, select lighting fitting by examining photometric characteristics and mechanical performance that meet installation, operating and maintenance conditions.
3. Select and arrange these fittings so that it will be easy and practical to clean and maintain them.
4. Balance, all the economic factors including initial, operating and maintenance costs, versus the quantity and quality requirements for optimum visual performance.
5. Control the light to control glare, shadow, distribution and diffusion.
6. Luminaries with some upward components of light are preferred for most area because an illuminated ceiling or upper structure reduces luminance ratios between luminaries and the background. The upward light reduces the 'dungeon' effect (feeling underground) and creates cheerful environment.
7. Higher mounting heights (out of the normal field of view), better shielding of the light sources and top openings in luminaries to allow to move dirt particles upward should also be considered.
8. Where false ceiling is provided, the lighting fittings may be recessed in the ceiling giving a more streamlined appearance to the whole installation.
9. Generally a continuous mounting of tubular fluorescent tubes fitting is preferred to an arrangement of reflectors at intervals.
10. The fittings should be fixed to the existing members of the roof structure and should be oriented according to the layout of the machinery to obtain most satisfactory result. The trenching system (metal channels with cover plates at the bottom, of standard lengths joined together) running across the hall with suspensions at necessary intervals is also preferred.
11. Illumination values and brightness ratios must be carefully controlled so that workers in one part of the factory are not subjected to higher brightness than they see in their immediate surroundings.
12. Contrasts between the high brightness of glazing and the dark solid surface around it should be minimised.

Calculation of Artificial Lighting : Following four methods are in use to calculate artificial-lighting installations in industrial buildings.

1. **The Light Source Point Method :** It is applied to calculate lighting fixtures where light sources are localised. Illuminance of inclined planes and uniformity of general illumination (exclusive of reflected flux) are determined.

2. **The Wattage Method :** It is simple and uses the formula W = PS/N, where W is the wattage of a light source in watts, P is the power density in watts/ 2, S is the surface (room) area in MZ and N is the number of light sources (lamps) in the lighting fixture. The values of P are available from appropriate tables.

3. **The Graphical Method :** This method of Prof. Trukhanov is most useful when light sources are projectors. It uses specialised nomograms.

4. **The Method of Light Flux Utilisation Factor :** It is most useful to calculate general uniform lighting in industrial building. It uses the formula F = ESKZ/UN where, F = light flux (lx), E = illuminance (lx), S = area of enclosure (m2), K = correction factor for the luminary's soiling (from a table), Z = the lighting nonuniformity coefficient, U = the light flux utilisation factor of a lighting fixture and N = .the number of lighting sources (lamps). The method takes into account both the direct light from the luminaries and the light reflected from the walls and the ceiling.

6.4 Plant Lighting Design:

Entire plant lighting shall be divided into following three categories.

(a) Normal AC lighting.

Normal lighting panels shall be supplied by three phase and neutral 415 V power derived from Main lighting distribution boards. LDB shall be supplied from PCC/MCC.

(b) Essential AC lighting.

Critical lighting will be provided on escape route within the control room building, substation building etc. These lights will be normally 'OFF' & Turn 'ON' automatically only on complete Power failure.

Essential light will remain energised all the time.

(c) Critical DC lighting.

The critical lighting shall be supplied by 220 V DC system having battery back-up.

Essential lighting panels shall be supplied in the same manner as the normal lighting panels but from the emergency board which has the back up of a stand by Power.

Portable emergency lights with built-in battery and battery charger shall be provided at strategic locations in building like Administrative building, Main control room. First Aid Centre, Fire Station, Warehouse, Workshop etc.

As far as possible the distribution boards shall be split so that loss of one board will not darken the area completely.

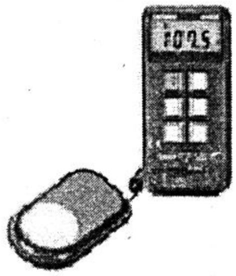
Building such as Substation, Control room, Office building. Canteen etc. shall be illuminated by fluoreocent fixtures. Process area shall be lighted by HPSV/HPMV/lamp fixtures. HPSV/HPMV lamps shall be used for yard and street lighting. Street lighting shall be automatically controlled by syncronizing timer. Tallest structures shall have aviation warning lighting as per statutory regulations.

All lighting fittings and associated conduit fittings shall be of a fully weather proof type certified for the area in which they are located.

Provision shall be made for switching off the outdoor area lighting, including street lighting from plant control room. The switch shall be lockable type.

Photometer (Luxmcter):

This is the common instrument to measure the intensity of illumination. It works on the principle that if equal illumination is produced on similar surfaces illuminated normally by two light surfaces, the ratio of their intensities equals the square of the ratio of their distances from the surfaces.



Photoelectric photometer is a device in which the light is measured by the current from a photo-electric cell. One such instrument is the luxmeter which is a portable photometer operating on the contrast principle and employing a variable aperture. To take a measurement at a given point, it is enough to expose the photo-cell to the light flux in the plane parallel to the work place and take the reading on the scale. A digital lux meter is shown in the figure.

Operating instructions include (1) Zero adjustment to set the pointer at zero position. (2) Inserting lumidisc into the light receptor. (3) Setting of lumidisc for ordinary measurement (0-5000 lux), high level measurement (5000 - 50,000 lux) or low level measurement (0 - 1000 lux).

Measured values are to be corrected by multiplying by the correction factor.

7 EFFECTS OF COLOUR ON SAFETY

What is more perceived? Colour or light? What the eyes see is colour and colour contrast, rather than light.

Lighting and colour are complementary and their effects are interdependent. Therefore, they are considered together in this Chapter.

No lighting scheme can be fully effective unless supplemented by well chosen and well maintained coloured surfaces.

7.1 Need of Colours :

Environments for work, play or relaxation have to be created and maintained. The colour and lighting influence vision and contribute to ' the wellbeing, morale, attitudes, housekeeping, quality, productivity, health and safety. In industry colours are used to :

1. Improve lighting conditions.
2. Decorate the environment.
3. Increase efficiency and productivity.

4. Improve quality of workmanship and normal skill.
5. Improve labour morale and interest in work.
6. Reduce accidents and increase safety.
7. Reduce 'rejects'.
8. Reduce absenteeism.
9. Raise standard of good housekeeping..
10. Improve building and machinery maintenance.
11. Reduce hidden costs of dull and gloomy atmosphere, and
12. Improve overall psychological and physiological effects on workers for better work performance.

7.2 Reflection Factors (LRV) :

A surface reflects light. The amount of light reflected will depend on the colour scheme of the surface. Pure white will reflect 100% and pure black 0% of light falling on them and reflections factor of other colours will fall in between. The recommended reflection factors, also known as light reflectance value (LRV), for interiors are :

Part	Colour	LRV
Ceiling	White	80-90%
Walls	Light colour	50-75%
Furniture, equipment, machinery, desk etc.	Light to medium colours	30-50%
Floors	Medium to dark colours	15-30%

Light reflectance values (LRV) of some colours are as follows :

Colour	Percentage of reflected light
White	85 to 90
Yellow	Light 75 medium 65
Grey	Light 75 medium 55 dark 30
Green	Light 65 medium 52 dark 7
Blue	Light 55 medium 35 dark 8
Ivory	Light 77 over green or white stippled 40
Cream	Light 66
Buff	Light 56
Brown	Dark 10

Appropriate colour should be selected from above two tables which conclude that ceilings and walls should have light colours for more reflection and floors, furniture and equipment should have medium to dark colours for less reflection. Colour can be used as a factor to reflect light to increase it.

7.3 Colour Code and Safety :

7.3.1 Indian Standards :

IS to be followed are : Code of practice for safety colours and safety signs 9457, Pipelines, identification, colour code 2379, Standard colours for building and decorative finishes 1650, pipelines in thermal power plants 9404, Identification for canisters and cartridges 8318 and Gas cylinders and related medical equipment 3933.

7.3.2 Colours to Identify Hazards :

Colour coding is most desirable and useful for safety purposes. Standard colours are used to identify hazards as follows :

Red	-	Fire protection, prohibition, danger, emergency stops on machines, red cross on medical facilities.
Yellow	-	Risk, danger or caution, hazards of slipping, falling, striking etc., flammable liquid storage, yellow band on safety cans, material handling equipment viz. lift trucks, cranes, crane hooks, caution, transport equipment, obstructions, change in floor level, stair nosing etc.
Green	-	Safety equipment not identified elsewhere, safety board, safe condition.
Blue	-	Warning and information signs, bulletin boards, rail road uses. It indicates safety colour only if used with a circular sign.
Orange	-	Dangerous parts of machines or energized equipment such as exposed edges of cutting devices, inside of movable guards, enclosure doors, transmission guards, electric installations.
Purple	-	Radiation Hazards
Black & White	-	Housekeeping and traffic markings. Also used as contrast colours.

White is a contrast colour for red, green and blue. Black is a contrast colour for yellow.

The piping in a plant may carry harmless or hazardous contents. Therefore it is highly desirable to identify them. Some standard colour coding is as follows:

Content in the piping	Colour
Flammable or water for fire protection	Red
Dangerous (hazardous chemical)	Yellow
Safe (water, air)	Green
Protective material (inert gas)	Blue

The proper colour may be applied to the entire length of the pipe or in bands 20-25 cm wide near valves, pumps and at repeated intervals along the line. The name of the specific material should be stencilled in black at readily visible locations such as valves and pumps. Piping less than 3/4 inch diameter is identified by enamel on metal tags. Anti-resistant colours should be used where acids and other chemicals may affect the paints.

Following colour coding is also useful in identifying pipelines (IS:2379):

S. No.	Material	Colour
1.	Water	Sea green
2.	Steam	Aluminum, IS 2339
3.	Air	Sky blue
4.	Acids	Dark violet
5.	Alkalis	Smoke grey
6.	Gases	Canary Yellow
7.	Hydrocarbons/ organic compounds	Dark admirality grey
8.	Mineral, vegetable and animal oils, combustible liduids.	Light Brown
9.	Other liquids / gases which do not need identification	Black

Entire length or a portion, more than 30 cm, of a pipeline should be painted so that it should not be mistaken for a colour band. The colour bands are superimposed on the ground colour, applied at start, near valves, joints, bends and end points. For a longer pipe, interval may be 50 m. Minimum width of colour band should be as under :

See Part 8.4 & 13.1(4) of Chapter-18 for colours of gas cylinders and pipe lines.

7.3.3 Accident Prevention Signs :

Accident prevention signs arc most widely used safety measures in industry. Their uniformity in the colour and design of sign are essential. Employees may be unable to read English or may be colour-blind and yet react correctly to standard sign. Following colours are normally used for signs :-

Sign	Colour
Danger Immediate and grave danger or peril.	Red oval in top panel; back or red lettering in lower panel.
Caution Against lesser hazards.	Yellow background colours; black lettering.
General Safety	Green background on upper panel; black or green lettering on lower panel.
Fire and Emergency	White letter on red background. Optional for lower panel; red on white background.
Information	Blue for bulletin boards.
In-plant Vehicle Traffic	Standard highway signs.
Exit Marking	See Life Safety Code, NFPA 101, Section 5-10.

Different types of Accident prevention signs are shown in fig. 9.1. See Fig. 18.1 in Chapter 18 also.

7.3.4 Painting of Plant and Machinery :

No lighting scheme can be fully effective unless well-chosen (and well-maintained) finishes are provided on main interior surfaces such as ceilings, walls, plant and equipment. The main object is to use colours which will reflect rather than absorb light. Diffused light thrown back in this way can contribute substantially to the total illumination on the work. It also improves the quality of the lighting by softening shadows and minimising harsh contrasts in the field of view, thus contributing to visual comfort and efficiency.

Because of full reflection of light, to paint the plant and everything by white colour is not advisable, because 'only white' .premises and equipment cause fatigue and boredom and are no incentive for active or creative work if there is no combination of other colours. Any extreme should also be avoided.

For ceilings, the reflection factor should be at least 75% which means white or near-white. A matt finish is preferable.. Aluminium paint is not recommended.

Walls are best finished in light pastel colours in the 50-75% range, except in the case of very brightly lit walls (e.g. those adjacent to a large window) which may need toning down to 40% or less to prevent them from becoming too glaring. Conversely, walls containing windows (but which receive no direct light themselves) cannot often be painted white with advantage.

Furniture should preferably have a reflection factor of at least 20%, and the modern blond (pale yellow) wood finishes and light grey paints for steel cabinets are preferred to the old-fashioned dark stained wood and dull olive green finishes. On desk and table tops which form a background to the work, it is important to guard against distracting reflections.

Floors should not be too dark. Practical considerations usually govern the nature of the floor finish, but 20-25% or so is. generally a satisfactory figure. Floor finishes which are very much lighter than this should be treated with caution since they can sometimes cause glare (e.g. particularly well-lit office interiors).

A well painted machine inspires feeling of personal pride and proper maintenance is encouraged. Under the General Code of Practice for Machine Guarding it has been provided that:

Colour schemes for machines be so selected as to cause least visual disturbance to the operator. Colour schemes should provide quite finishes of medium reflectance and should separate critical from non-critical areas of the machine. Critical 'areas are those which might constitute danger points or which need to be instantly visible. These should be painted in local colours i.e. colours which command attention (Red, Orange, Yellow). Non-critical areas are those which should be kept in the background. These should be painted in "Static" colours (Cream, Stone Grey, Pale Green, Pale Blue). Control areas should be painted in suitable colour to provide a neutral background for coloured indicator plates.

Guards should be regarded as part of the machine and should be painted in the same colour as the colour of the machine. Colouring recessed surface of machines with lighter shade than used for the outer surfaces help to minimise the effect of shadows on the inner surfaces (Example : Static grey for outer surfaces, static stone for recessed surfaces).

Identification colours on machines should be reserved for things which really matter, such as stop buttons and other safety tripping devices which must be found quickly in an emergency. "Safety colours" must also be used with great restraint. Dangerous moving parts should be guarded, not coloured, and when guarding is impossible, colour should be used to highlight the actual hazard and not merely as a general warning.

For paints IS : 5 and for building and decorative finishes IS : SP 1650 are relevant.

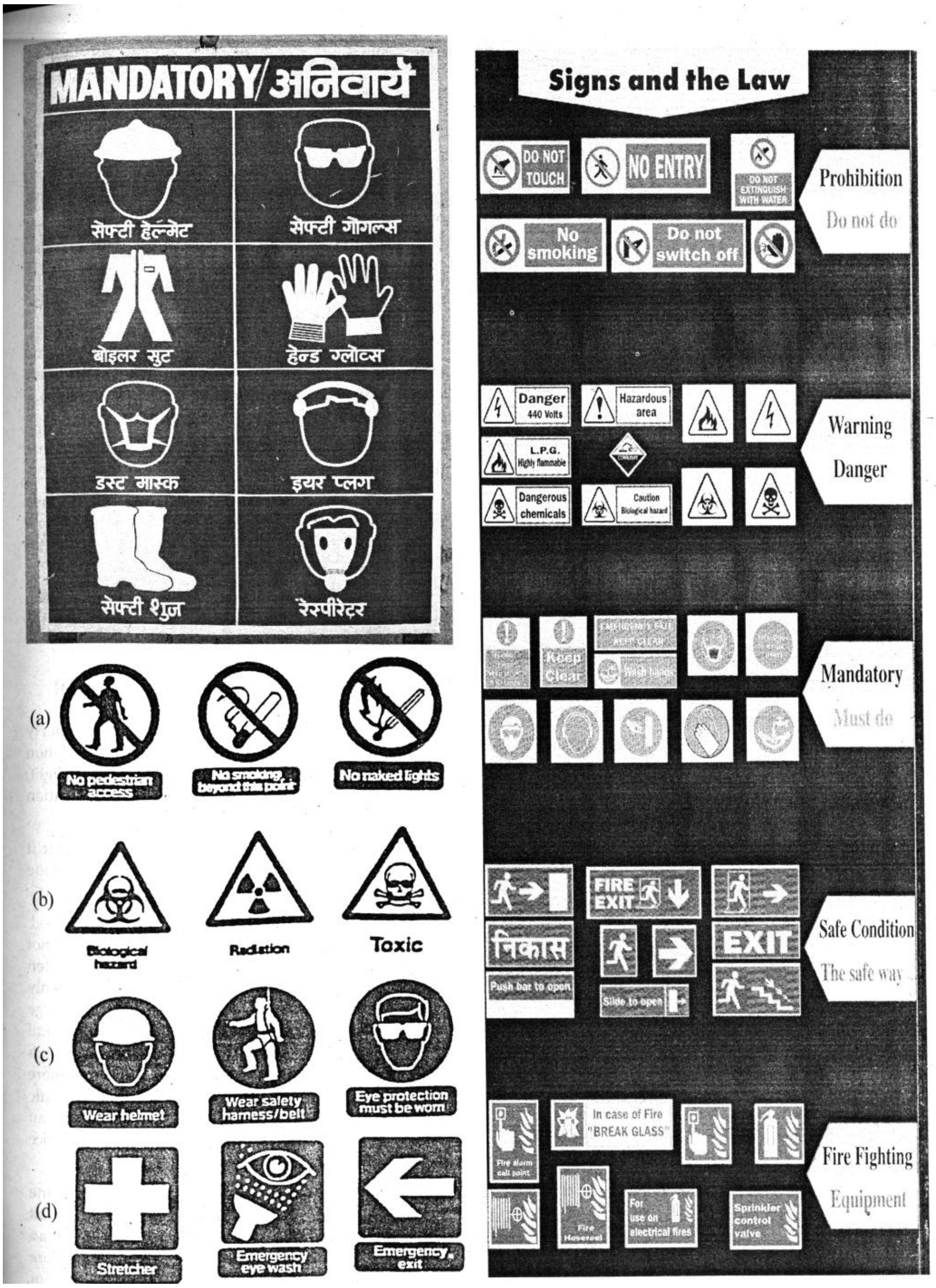


Fig. 9.1 Accident Prevention Signs : (a) Prohibitory (b) Warning (c) Mandatory (Legal) (d) Safe Condition

7.4 Psychological Effects of Colour :

They are as follows :

Colour & other parameter	Psychological Effects
Red	Stimulates, activates, energises
Yellow	Bright, Gray, Fresh like sunshine
Orange	Tension producing
Light Green Light Blue	Relaxed feeling, improve morale
Purple	Feeling of depression

White	Stimulating if it is used with warm colours
Black Size	Not depressing if it is used with other colours Green and Blue objects look larger than Yellow and Red
Space	Green and Blue surfaces record. Red and Yellow come forward.
Temperature	Red and Yellow give warm feeling. Blue and Green give cool feeling.
Weight	Bright colours make objects look lighter.

Red, orange and yellow (light) are warm colours. Blue, turquoise and green are cool colours. Off-whites and pastel tints are light colours. Black, grey and deep tones are dark colours and red, yellow, yellow green, orange and red-orange are considered bright colours.

Warm colours may be used to obtain activation and relaxation effects i.e. energy input. Cool colours are aid to energy output. Bright colours give an impression of useful place and lightness and produce calm and peaceful effect. Dark colours may have a cheerless and depressing effect.

In selecting colours following guideline is useful -

1. Natural white or light colours are safe and render all colour shades in true proportions.

2. Cool colours on objects give good effect. Therefore they are called safe object colours.

3. Bright colours should 'be preferred as background colours. More saturated richer colours should be preferred for objects. The sensation of colour of an object depends on the colour of the background.

4. Sources emitting warm colour of light, render warm colours of objects. The proportion of short-wave radiation makes cold colours ineffective.

5. Yellow seen against a black background will be luminous but will loose its luminosity when seen against white. This effect (simultaneous contrast) is true with all colours and shades.

6. When seen against black, every colour becomes brighter and against white paler. This is called successive contrast.

7. Colours can affect their background also (Bezoll's effect).

These rules emphasise importance of and interaction between light and colour. The appropriate light has to be chosen with colour and vice versa.

While designing colour schemes for plant and equipment, these factors are to be taken into consideration.

This discussion concludes t1iat the question of colour may not just be left to the painter, nor the question of light to the electrician. Scientific knowledge of combined effects of lighting and colour should be properly utilised.

Colour liking may change with time and fashion but safety aspect should not be forgotten.

8 MAINTENANCE FOR LIGHTING AND COLOUR

Unless a lighting installation is properly maintained, lamp depreciation and dirt accumulation on the fittings will cause an increasing loss of light; in some circumstances this can cut the illumination level by half in the period of only a few months.

When choosing equipment, make sure that it will be easy to clean and re-lamp, and also provide safe and ready means of access to the units.

Cleaning schedules should be carefully planned. Fittings should be cleaned at regular intervals and not just when a lamp fails. The need .for this is often overlooked because dirt collects so slowly and evenly that a deposit which may be absorbing a large proportion of the light is often difficult to detect until it is disturbed. Cleaning should be done often enough to prevent the illumination level from dropping more than about 20-30% during the interval. A systematic check with a light-meter at several fixed points in an installation is one way of deciding how often to service it.

Lamp Replacement should also be done systematically, and it is not always advisable to wait until they actually fail to light. The output of an incandescent lamp does not drop a great deal before it finally burns out; but this is not necessarily true of the fluorescent type, which may continue to strike Long after the light output has dropped to a very low figure.

Group replacement of all the lamps together at some predetermined time is often favoured for large retaliation in which many units are in use for approximately the same number of hours each day This group replacement takes place after the installation has burned for a fixed number of hours, or after some fixed proportion (say 20%) of the lamps has failed.

E X E R C I S E

1. Explain, State, Mention or Discuss:

1. Need, purpose or benefits of good lighting.
2. Effects of bad or poor lighting.
3. Requirements of good lighting.
4. Daylight factor. Reflection factor and Utilization factor for light.
5. The difference between –
   - (1) Illuminance and Luminance.
   - (2) Initial and service illuminance.
   - (3) Adequate and uniform lighting.
   - (4) Quantity and quality of light.
   - (5) Luminance contrast and colour contrast.
   - (6) Direct glare and Disability glare.
   - (7) Discomfort glare and Reflected glare.
   - (8) Glare and Shadow
   - (9) Day (natural) lighting & Artificial lighting.
   - (10) Mercury vapour lamps & Sodium vapour lamp.
   - (11) Incandescent lamp & Fluorescent lamp.
   - (12) Effect of white colour and black colour.
   - (13) Portable emergency light & Local light
6. Types of lighting.
7. Factors of selection of light sources or lamps.

8. Different sources of lighting commonly used in a factory and discuss their merits and demerits.
9. Following terms: (1) Luminous flux (2) Luminous intensity (3) Illuminance (4) Brightness (5) Background and (6) Contrast.
10. Advantages of good lighting.
11. Recommended standards of illumination with few examples.
12. Importance of illuminance level.
13. Criteria for selection of lighting fittings.
14. Basic or general considerations for design of lighting installation.
15. Design factors for Day lighting of factory building.
16. Design factors for artificial lighting in factory building.
17. Categories of plant lighting.
18. Effects of colour on safety.
19. Choice of colour for plant and machinery.
20. Psychological effects of colour.
21. Need of maintenance for lighting & colour.
22. Colours and signs for accident prevention.
23. Different ' methods to derive maximum advantage of natural lighting in a factory building.

2. Write Short Notes on :

1. Sight and light.
2. Studies and results of lighting effect.
3. Light loss factors and reasons of light losses.
4. Adequate illumination.
5. Glare OR Shadow.
6. Uniform lighting
7. Colour effect
8. Flicker and stroboscopic effect
9. Day lighting
10. Artificial lighting and their types
11. Types of light sources or lamps (tubes)
12. Types of lighting fittings
13. Types of lighting installations.
14. Colour rendering index.
15. Illuminance ranges
16. Methods of calculation of artificial lighting
17. Photo (lux) meter.
18. Colour and light reflection factors or Light Reflectance Values (LRV)
19. Colours for accident prevention signs.
20. Colour scheme for machines
21. Cleaning scheme for lighting fittings
22. Statutory provisions for lighting in factories.
23. Need to allow upward light toward roof or ceiling

3. Comment on following stating whether it is true or not:

1. Eyes, sight and light are interdependent.
2. Good lighting increases safety and bad lighting decreases it.
3. Contrast should be appropriate.
4. Illumination level (standard) cannot be fixed for all persons and places.
5. Colour has no effect on lighting.
6. Lighting and colour are complementary.

7. Guards should have different colour than that of the machine.
8. Ceiling, floor and wall should have different colours.
9. Colours have no effect no mind.
10. Group replacement of lamps has advantages.
11. Good artificial lighting improves work performance and safety.
12. Indian Standards mentioned in this Chapter.

Reference and Recommended Reading

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CHAPTER – 10

Ventilation and Heat Control

THEME

1. PURPOSE & EFFECTS OF VENTILATION AND HEAT CONTROL

Clean, fresh and uncontaminated air is a basic need of life. Industry has many pollutants which contaminate air and heat stress is generated due to hot processes. Well designed and effective ventilation provides solution to these problems.

1.1 Purpose of Ventilation and Heat Control:

The need or purpose of ventilation and heat control are summarised here as follows :

1. Air is life and fresh air is the first need for survival of living creatures. Absence of air brings death within a few minutes. Life without breathing is not possible and the clean air is needed for the whole life- for breathing and functioning of human body. Therefore good ventilation giving sufficient fresh air is the permanent requirement.

2. Human body cannot tolerate excessive temperature. Heat stresses produced by very hot or cold exposures cause adverse effects on health and safety of work people. Therefore

environmental temperature control is also permanently needed for well functioning of human body. Ventilation helps in removing excessive temperature.

3. Heavy physical work or heavy work load causes heat stress and strain and increase metabolic heat, body temperature, sweating, heart rate etc. To maintain (control) body temperature, ventilation is necessary. See Part 5.1.

4. Carbon dioxide is continuously exhausted by all human beings. Much more contaminants are added by manufacturing processes to pollute air. Therefore cleaning of air and supply of fresh air with sufficient oxygen are also necessary. This is possible by good ventilation and pollution control techniques only.

5. Where due to weather or atmospheric conditions or process parameters, excessive temperature is unbearable or uncomfortable, air conditioning or HVAC systems are also necessary. Conversely where air heating is necessary as in case of excessive cold climate, it must be provided.

6. Basic functions of ventilation are to (a) maintain the oxygen content of the air and to prevent CO, concentrations from rising (b) prevent or removal of body odours (c) prevent harmful concentration of aerosols and air-borne contaminants and (d) maintain reasonable conditions of thermal limits for comfort and efficiency which result in decreased heat stress, increased productivity, reduced accident rates (hot conditions induce unsafe acts) and adverse health effects (interaction with other hazards), higher level of job satisfaction, reduced absenteeism, improved attitudes, reduced downtime for hot vessels and compliance of required standards.

7. While designing industrial buildings care must be taken to provide good ventilation for dilution of inside air to prevent vitiation by causes, such as body odours, to remove process released contaminants and heat exposures to maintain satisfactory thermal environments, to maintain heat balance of body and to prevent acute discomfort and injury to the health of the workers. If natural ventilation is not sufficient for these purposes, mechanical ventilation, cooling system or other techniques must be employed to achieve satisfactory results.

8. As explained in subsequent part 5.1 & 5.2 of this Chapter, the basic need for ventilation is to maintain the body heat balance equation by controlling air and surrounding temperature, humidity and air velocity. Therefore supply, well distribution and maintenance of fresh air throughout the factory are utmost necessary to maintain comfortable working conditions as expected by sections 13 to 15 of our Factories Act.

Thus main purpose of ventilation is to remove heat 'and contaminants from air in residential or industrial building and to supply or regulate fresh and cool (or hot) air for the comfort of the occupants or workers.

The term industrial ventilation refers to ventilation systems for the industrial use. Main four functions of ventilation are (1) to supply sufficient fresh air (2) to distribute it throughout the work room (3) to remove polluted and hot air and (4) to maintain comfortable working conditions.

Mainly ventilation is employed for human comfort and therefore called comfort ventilation or air-conditioning. It is also employed for process control by mechanical ventilation (process ventilation) as explained in Part 7.3.2.

The quantity and quality of air required for ventilation depend upon -

1. Rates of heat generation in the room.

2. Rates of contaminants (gas, vapour, dust) generation in the room.
3. Rates of dispersion of heat & contaminant.
4. Rates of dilution and/or removal that may be achieved by ventilation.
5. Electric fittings for ventilation system in flammable/explosive area should be flameproof and of the approved type.

1.2 Effects of Good and Bad Ventilation:

From above discussion, effects of good and bad (poor) ventilation are inferred as tinder -

Effects of good ventilation are:

1. Availability of sufficient fresh air for breathing or life.
2. Removing oxygen deficiency from a confined space.
3. Removal or dilution of carbon dioxide and other air pollutions.
4. Decrease in environmental heat or temperature.
5. Increase in air changes per hour as per statutory requirement.
6. Maintaining metabolic body temperature or heat balance.
7. Removal of air contaminants (dust, gas, fumes, mist etc) from work room.
8. Maintaining room temperature for comfort
9. Providing desired air conditioning (cooling or heating).
10. Removal of body odour and bad smell from the room.
11. After heavy physical work, evaporating body sweating and making the body cool.
12. Decreasing discomfort and distress.
13. Maintaining efficiency of work.
14. Decreasing chances of accidents and maintaining safety and productivity.
15. Providing better job satisfaction and good attitudes.
16. Increasing cooling rate of hot vessels or hot substances.
17. To maintain overall comfortable working conditions and
18. To help compliance of statutory provisions and standards.

Effects of bad ventilation are opposite to above i.e. non availability of fresh air for life, insufficient air changes, no cooling effect, discomfort, body stress and strain, no removal of air contaminants, body odour, bad smell etc, increasing chances of accidents, lowering efficiency and productivity, no job satisfaction, more time for cooling of hot vessel and substances and violation of statutory provisions etc. See Fig. 10.1 to 10.4.

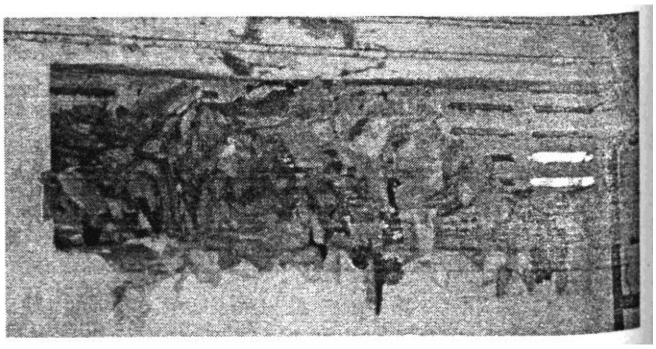
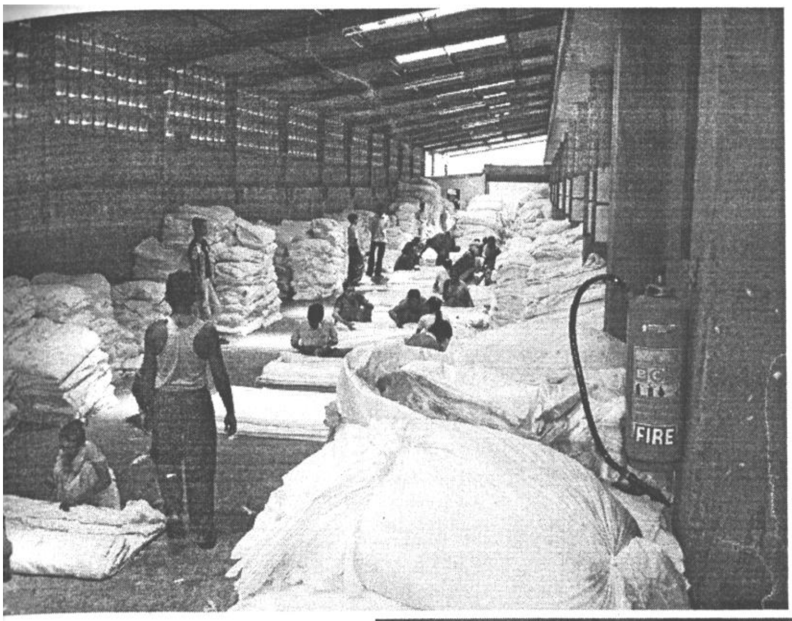
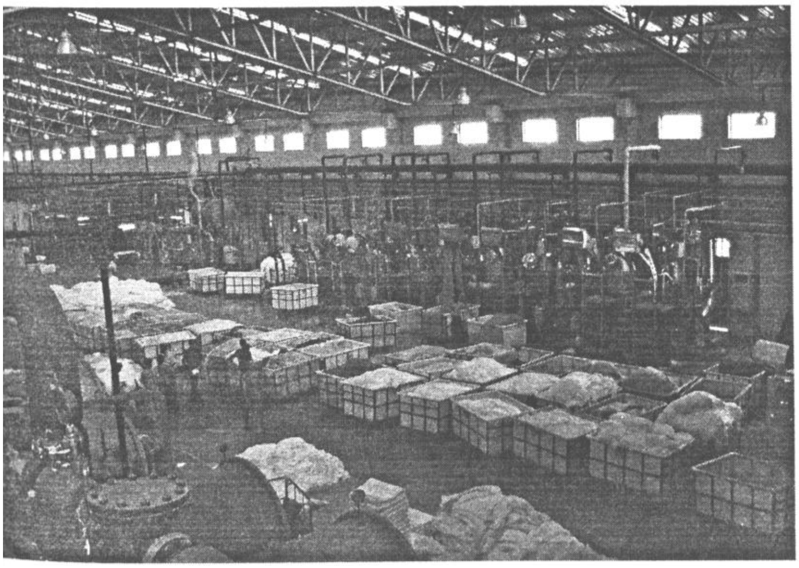


Fig. 10.1 Ventilator is badly obstructed



← **Fig. 10.2** Hazard - No Windows for passage working

Fig. 10.3 Hazard - No Windows and Closed Ventilators →



← **Fig. 10.4** Hazard - No Windows and fixed glass Ventilators. Poor Ventilation.

2 STATUTORY PROVISIONS

Sec. 13 of the Factories Act requires effective, suitable and adequate ventilation in every factory, by the circulation of fresh air and such a temperature to provide comfort and prevent health injury to workers. It also requires well designed walls, roofs and insulation of hot parts to reduce the excessive temperature.

Sec. 14 requires local exhaust ventilation at the source of dust, fume or other impurity, with the enclosure (hood or cover) on such source (point of origin), to prevent inhalation and accumulation in the workroom, of such injurious or offensive dust and fume.

Sec.l5 provides for artificial humidification and rules 19 to 29, GFR, prescribe dry and wet bulb temperatures, details of hygrometer and manner of introducing steam.

Sec. 16 calls for 'a minimum 14.2 m" (height 4.2 m max.) of breathing space per worker.

Sec.36 and 37 prescribe for venting dangerous gases from a confined space and safety measures including work permit, self breathing apparatus and safety belt before allowing entry to such confined space.

Rule ISA of the Gujarat Factories Rules (GFR) prescribes workroom temperature 30 "C (86°F) at a height of 1.5 mt, air movement of at least 30 m/min with 6 air changes per hour, a schedule for dry and wet bulb temperatures and ventilating area more than 15% of the floor area. See Part 6.4 for details.

Rule 102 (GFR, 1963) and many Schedules there under require effective local exhaust ventilation on dust/fume/gas generating processes and their test report in Form No. 26A.

New rule 12B prescribes Form No.37 for work environment monitoring. Rule 68G for ovens and dryers and new schedules 2,11,17,19,25 and 26 u/r 102 GFR, also require appropriate local exhaust ventilation for dust, gases etc.

3 INDIAN STANDARDS

Some IS are: Ventilation - industrial 3103, natural, of residential buildings 3362, in petrochemical plants and refineries 12332, mechanical on ships 5858, tubing, PVC 3768., Specification for roof extractor units 3963. Ventilation ducting, metal duct '655, Vinyl coated, semi-rigid 12814., Ventilator - aluminium 1948, cabin 3941, chain 3828, cowl 3271, frames timber 4021, gooseneck, welded, pipe 3274, metal, code of fixing and glazing 1081, mushroom 3279. Venturi meters for fluid flow 4477., Specification for propeller type AC ventilating fans 2312., Electro-heat installation 9080. Air conditioning safety code 659. Mechanical refrigeration, safety code 660, Air pollution - glossary of terms 4167. methods of measurement 5182 (part 1 to 20), in petroleum refineries 10179, Ambient air quality limits - units for measurement 9620, from fertiliser industries 8635, from petroleum refineries • 8636, from cement plants 10693, from mmf plants 9233 from diesel vehicles 8118, for CO from spark ignition engines 9057., Ringelmann smoke charts 9078 micrometeorological techniques 8829.

The use of first mentioned IS:3103, Code of practice for industrial ventilation is strongly recommended for engineers, as it provides details of safe design, installation, operation, testing and maintenance of ventilating systems regarding general and dilution ventilation for industrial process and measures of heat control in such process. It explains 23 definitions also.

4 THERMAL ENVIRONMENT AND ITS MEASUREMENTS

Before controlling temperature, humidity and air movement it is necessary to measure their adequacy. Subsequent measurement is also necessary for the, satisfaction that whether they are properly controlled or not. Some methods and equipment are explained below for this purpose.

4.1 Temperature Measurement:

The mean radiant temperature of the surroundings is calculated (not measured) from the values of dry bulb air temperature, the glob temperature and the air velocity.

Thermometers placed at the height 1.5 m above floor level and not within I m from any heating device are used to measure the air temperature. For precise measurement and recording of temperature, thermographs are used. Recording period may be as per requirement.

The Glob thermometer is a black-painted (mat), hollow copper sphere, 15 cm in diameter, into which a thermometer is inserted. It therefore measures temperatures which include radiant heat effects. It is preferable to a dry-bulb thermometer. Rule 18A(1) of the • Gujarat Factories Rules 1963 provides for a glob thermometer of 15 cm dia to be kept in the environment for not less than 20 minutes and consideration of the temperature recorded by it, if it exceeds the dry-bulb temperature of the air.

The glob is suspended at the point of measurement, about 1.2 m above the ground, not contacting any solid. Thus the globe gains heat by radiation and loses by convection (not conduction). When thermal equilibrium is reached (by @25 minutes)/ the reading in the thermometer gives the globe temperature tg.

4.2 Humidity Measurement:

Psychrometers or wet and dry bulb hygrometers are used to measure relative humidity of the air. **Hydrographs** are used for continuous recording of the air humidity where the humidity requirements are most stringent. The two temperatures of dry and wet bulbs are used with a psychometric table or chart to determine relative and absolute humidity, dew point and other conditions of an air-water mixture. The direct dial hygrometers are also available.

A whirling hygrometer (sling psychro-meter) is used to assess the ambient air temperature and humidity. The dry and wet bulb assembly is rotated at 60 rpm till the readings become steady. The reading of the dry bulb gives the ambient temperature while drop between dry and wet bulb temperature is an indication of relative humidity by using a psychometric chart.

4.3 Air Movement and Content Measurement:

For recommended values for air movement and air changes See Part 2 and 6.4. Values recommended by IS:3103 are as under -

Anemometers (Velometers) are used to measure the velocity of the air. The revolving - vane and the revolving - cup types are in common use. The Vane anemometer consists of eight vanes fixed on a hub at 45Q to the air stream and pivoted so as to rotate in a vertical plane. The speed of rotation is indicated on a dial calibrated to read air velocity from 0.3 to 5 m/s. 77ie Cup anemometer consists of four hemispherical cups carried on the ends of four radial arms pivoted so as to rotate in a horizontal plane. The speed of rotation is indicated on a dial graduated to read air velocity from I to 20 m/s. Velocities under 0.3 m/s are measured by means of a microanemometer or electrical thermal anemometer.

Kata thermometer designed by Leonard Hill in 1914 measures the cooling power of the air to cool skin surface, a power that is measured in terms of dry-bulb temperature, the radiation and the rate of air movement. The kata thermometer is an alcohol, liquid - in glass thermometer with a large bulb and an upper reservoir. There are two marks on the stem. It is cheap but fragile and useful for low air velocities below 0.25 "V s (50 fpm). The bulb is warmed by a warm water so that the alcohol fills up the whole thermometer (up to 40 "C). The thermometer is then carefully dried and placed at the sampling point.

The cooling time is measured .by a stopwatch. Then air velocity is calculated by using the values of cooling time, air temperature and instrument factor.

Swinging van anemometer. Hot wire anemometer (anemotherm air. meter), Alnor thermo-anemometer, Mechanical anemometer. Thermistor Bead anemometer, Heated thermocouple anemometer and Rotating vane anemometer of clock type or electronic direct-reading type are also used in industrial hygiene to measure the air velocity.

Pressure tubes are used to measure both pressure (total and static) and velocity of the air in air ducts. The dynamic (velocity) pressure is determined as the difference between the total and the static pressures. The air velocity in air ducts can be measured with a Pressure head device (static and pilot tube connected with differential pressure U-gauge).

Indication tube or Gas detection tube is used to measure contents of air contaminants such as toxic vapours and gases viz. Cl_2, CO, SO_2, NO_2, PH_2 ethanol etc. A common type is hermetically sealed glass tube about 4 to 7 mm wide and 100 mm long containing a filler (crushed silica gel, glass or porcelain crumbs) treated with solutions of various reagents. The tube is kept into intimate contact of the air to be analysed. By pump-strokes air sample is drawn in. The concentration of the impurity can be read on a scale by a length or rate of change in colour of the filler material that has completed reaction.

Air purity can be measured by air or gas analysers of various designs. Direct techniques of gas analysis-spectrometry, electrical-chemical and optical methods permit automatic and continuous air analysis. In air sampling method the samples collected by air sampler pumps, are analysed in a laboratory to get accurate measurement.

Indoor air quality monitors are direct reading instruments for gaseous sampling.

Dust contents in the workroom are determined by passing a measured\quantity of air through filters during a particular time and calculating the dust mass collected. Methods to measure character and size of dust particles are also available.

Following three parameters should be measured to assess the performance of ventilating systems :

1. Capture velocity.
2. Air volume flow rates in various places in the system.
3. The pressure losses across filters and other fittings and pressures developed by fans.

The design value of these items is specified by the manufacturer of the equipment. Therefore instruments and devices are required to

1. Measure air velocities in various places.
2. Measure air pressure differences.
3. Trace and visualise airflow patterns.

As stated earlier, air velocity can be measure(by vane anemometers or heated head (hot wire or thermostat) air meters. Anemometers are most suitable for open area (e.g. large hood and tunnel). While heated head air meters are more suitable for inserting into duct or slot but it is not suitable where flammable gas/vapour may be present. Average velocity (measured) multiplied by the area of the opening gives the volume flow rate.

Pilot-static tube is used to measure air velocity above 3 m/s. If <air flow pressure P (N/m2 or Pa) is known, considering air density d=1.2 kg/m3 for most ventilation situations, the air velocity V (m/s) is give by-

$$V = \sqrt{\frac{2P}{d}} \quad \text{or} \quad P = \frac{1}{2} dV^2$$

Pilot static tubes are thin and can be easily inserted into ducting. All velocity meters should be placed parallel to the air stream and calibrated from time to time.

Pressure difference in air can be measured by a manometer or U-tube gauges filled with water or paraffin. Diaphragm pressure gauges are also available.

Air flow patterns can be detected by smoke tubes which produce a plume of smoke when air is puffed through them. For airborne particles, dust lamp is used to see moving particles in a light beam.

See also Form No. 26A, GFR, for 'Test Report of Dust Extraction System'.

5 PHYSIOLOGY OF HEAT REGULATION

Heat effects on human body and their control measures are mentioned below. The other measures are described separately in parts 7 & 8 of this Chapter.

For physiology see Part 2 of Chapter-24.

5.1 Heat Stress and Thermo Regulation:

There are two types of animals - Poikilotherms whose body temperature equals the environmental temperature and Homeotherms whose body temperature fluctuates within a small range to maintain the temperature stability for metabolic functions. Human body maintains the temperature @ 36 to 39.5° C (96.8 to 103.1" F). To maintain this small range of thermal stability against too high or too low environmental temperatures, the homeotherms (which includes us) have to undergo some stresses which adversely affect performance and efficiency.

Heat Stress is the burden or load of heat that must be dissipated if the body is to remain in thermal equilibrium and is represented by the sum of metabolic heat (physical work) and environmental heat load. The environmental factors are governed by the air temperature, humidity, air movement and the temperature of surrounding (radiant heat exchange).

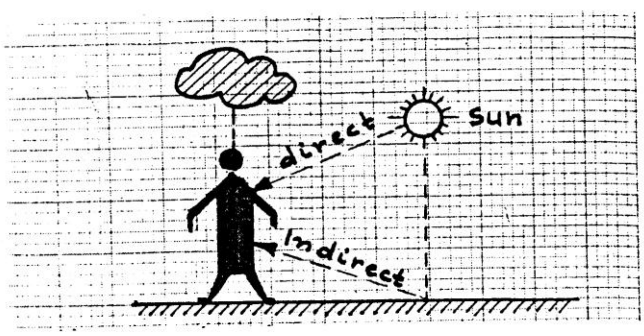


Fig. 10.5 Human body exposed to Sun a main source of heat

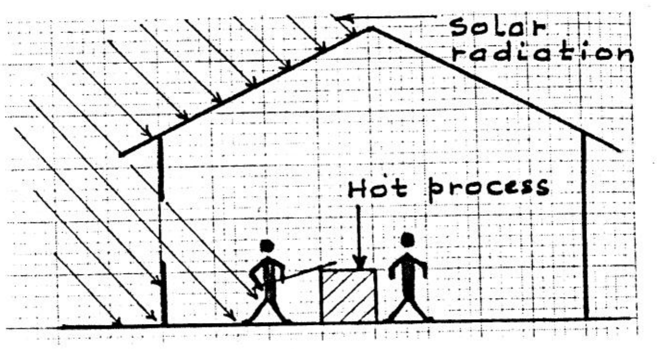


Fig. 10.6 Sources of heat - Solar radiation and -hot processes

Physical work contributes to the total heat stress of the job by producing metabolic heat in the body in proportion to the intensity of the work.

Clothing affects the heat stress. Cotton clothing is most comfortable as it soon absorbs sweating and dissipates heat. Synthetic clothing, though looks good, adds to sweating and increases heat stress.
Heat Stress of any given work environment is .considered as the combination of both climatic and non-climatic factors leading to heat gain by the body by convection and radiation and/or limiting heat dissipation from the body.

Climatic factors are : air temperature, humidity, radiant temperature and air movement.

Non-climatic (personal) factors are : metabolic workload (degree of physical work), clothing, age, sex, body build, acclimatisation, physical fitness and ethnic differences.

Heat Strain is the physiological or pathological change (response) resulting from heat stress viz. rise in body temperature, sweating, heart rate etc. The severity of strain depends on prevailing stress, age, physical fitness, degree of acclimatisation and dehydration of the worker. When the strain becomes excessive, discomfort or distress is felt. Acclimatisation helps to tolerate heat stress.

Heat Balance Equation:

$H = M - E \pm C \pm D \pm R - P - U$

Where

H	=	Amount of heat gain or loss by the tissues of the body. If the body maintains thermal equilibrium S = 0
M	=	Metabolic heat production. It depends on the rate of metabolism.
F	=	Evaporative heat loss. It partly depends on the sweating rate and partly on the climatic conditions, especially water-vapour tension and humidity.
C	=	Convective heat gain or loss } depends
D	=	Conductive heat gain or loss } on the
R	=	Radiant heat gain or loss } climatic } condition
P	=	Heat expanded in physical exertion
U	=	Heat loss due to respiration, exertion, urination etc.

A hot environment will increase heat gains by radiation, convection or conduction. Humidity retards heat loss from the body by evaporation. The body will attempt to balance any heat gain by perspiring to increase cooling by evaporation. If the loss of heat does not balance the gain, the body will suffer.

The rate of metabolism (metabolic rate) for a' sedentary i.e. seated adult is about 100 Kcal/hr but it increases in heavy work up to 1000 Kcal/hr. Heat balance equation suggests the factors determining heat stress as air temperature, air velocity, humidity, temperature of surroundings, degree of activity and clothing worn.

Therefore it should be the basic aim of any ventilating system to

1. Keep the air temperature in the room low enough to dissipate body heat by convection.
2. Prevent excessive humidity to help body heat loss by evaporation and
3. Regulate the air movement to help body heat loss by rapid evaporation.

Metabolic heat production (Metabolic rate) : It is the amount of heat produced in the body by way of metabolism which varies depending upon the level of activity.

Activity (Category)	Heat production (Metabolic rate) Kcal/hr
Basal condition	60-120
Light physical work	120-220
Moderately heavy physical work	220-320
Heavy physical work	320-420
Very Heavy Physical work	420-540

Convective heat gain or loss : Body gains or looses heat by convection depending upon the gradient between the skin and air temperature. It is modified by air movement. For a nude man, the following equation can be used to calculate the heat exchange by convection.

$$H = 0.5\ V\ (ts-ta\ )$$

Where H = amount of heat loss/gain in Kcal/m^2 of body surface area/hr,

V = air speed in ft/min,
t_s = skin temp. in ^{0}C and
t = air temp in ^{0}C.

Radiant heat gain or loss : Depending upon the level of radiant temperature (t_r) of the surrounding environment over that of the skin temperature (t_s) the body will gain or lose heat by radiation. The following equation represents heat exchange by radiation.

$$H_r\ (Kcal/m^2/hr) = 5.7\ (t_s - t_r)$$

Evaporative heat loss : Sweat produced on to the surface of the skin evaporates, when the vapour pressure on the skin is higher than the vapour pressure of the surrounding environment. Air movement enhances evaporative heat loss. By using the following equation, the heat loss due to evaporation can be worked out.

$$H_e = 1.4\ V\ 0.37\ (P_s - P_a)$$

Where

H_e = evaporative heat loss in Kcal/ m^2/hr,
V = air speed in ft/min,
P_s = vapour pressure of the skin and
P_a = vapour pressure of the air.

Factors affecting heat-balance of the body :

Heat-production is increased by combination of carbohydrates, fats and proteins. The factors are : Basal heat production (BMR) specific dynamic action of food (SDA), Higher BMR, Unconscious tensing of muscles, shivering and exercise.

Heat loss is increased by convection, radiation & evaporation. The factors are : Basal heat loss, increased air movement, increased radiating surface, increased insensible vaporisation, increased skin circulation, sweating, panting and decreased clothing.

5.2 Thermal Limits for Comfort and Efficiency :

The effect of atmospheric condition i.e. temperature, ventilation, humidity, radiant heat, greenhouse effect etc., upon worker's efficiency or susceptibility to accident is difficult to predict, because, it varies with person to person and one comfortable condition may be uncomfortable for others. Much variation from the body temperature 37°C (98.6° F) causes discomfort for the majority of factory workers doing light work. A dry-bulb temperature of 18°C (64° F) represents the most satisfactory condition and variations of 2 to 3 degrees from that seem to have little discomforting effect. In Indian atmosphere 20 to 30°C is the comfortable temperature for a variety of workers.

American Ventilating Engineering Association recommends the following ranges as the most acceptable:

	Place	**^{0}C**	**^{0}F**
1	Lecture Hall	16-18	61-64
2	Sleeping Rooms	12-15	54-59
3	Workshop (moderate activity)	16-18	61-64
4	Workshop (vigorous activity)	10-15	50-59
5	Bathrooms	20-22	68-72
6	Gymnasium	15.5	60

Some recommended upper limit values of comfortable temperature are as follows :

Consideration	Critical Effective Temp.	
	^{0}C	**^{0}F**
1. Safe tolerable limit for -		
(a) Light work	32	89.6
(b) Moderate work	29.5	85.1
(c) Heavy work	29	84.2
2. Prevention of steep fall in production	28.9	84
3. For efficient production	26.7	80
4. For thermal comfort in light / sendetary work	20-24.7	68-76.5

Effects on skin in contact with surfaces at different temperatures are also noted. Temperatures 160°F, 180°F and 212°F cause second degree burn on 60, 30 and 15 second contact respectively. 140°F gives pain due to tissue 'damage (burns) and temperature below 32°F also gives pain due to tissue damage (freezing). 120°F gives pain due to burning heat. 9U4°F gives warm or neutral feeling (physiological zero). 37 to 54°F gives cool effect and from 32°F and below gives pain due to freezing.

But the temperature alone is not a good indicator of comfortable conditions. In spite of above desirable level, discomfort may be caused because of frequent drafts (wind speeds), excessive moisture, undue dryness and high radiant heat. The recording and regulating of these factors and equating them with experiences of comfort, .and discomfort has been an old problem of safety engineers.

The effect of atmospheric conditions on output and accident rate has been demonstrated in a number of studies. The optimum temperature varies with the type of work that is performed and depends upon the state of health, age, clothing, diet and the ability of the employee to adapt himself to different climatic ' conditions.

Numerous studies have been reported showing a close relation between accident frequency and atmospheric conditions. One study of collieries workers indicates that at an average temperature of 16.5°C (62°F), the accident frequency and severity rates were minimum. Another study pointed out 21-23.5°C (70-74°F) temp. range to keep the accident rate minimum. One study of hourly accident rates inferred that the accidents were higher during the last hours of the day shift and the first hours of the night shifts.

Mental Work experiments of the New York ventilation commission demonstrated that such work maybe performed as effectively under humid (80%), hot 30°C (86"F) and stagnant air conditions as under optimum conditions of circulating air at 30°C (68°F) and 50% humidity. The influence of controlled ventilation on attitudes and labour turnover affects all types of workers and -a favourable attitude of workers toward the management is an indirect benefit which should not be overlooked.

Barometric pressure has little effect, whereas temperature and humidity have considerable effect on behaviour. Production was at its highest level when the temperature was 30°C (68°F) and the air was fresh and circulating. Using this as a base, it was noticed that stagnant air caused production to fall off® 9%. Relative humidity of 40-50% is desirable for comfort and hygiene. Humidity belmv 30% are undesirable as they may cause dehydration of mucous membranes of the nose and respiratory tracts.

Toxic effects of chemicals may be magnified when temperature is raised, because, toxicity of chemicals is known to increase due to temperature rise as follows :

	Chemical	Toxicity at	
		24 ^{0}C	35 ^{0}C
1	Carbon Tetrachloride	1	3.9
2	Carbon Monoxide	1	2.4
3	Amylnitrate	1	3
4	Lead	1	>1

Heat Disorders are noticed at higher temperatures. A man may collapse at core (body) temperature of 39.5°C (normal oral temp. 37°C). At about 40.6°C (105°F) the sweating mechanism fails and the core temperature rises sharply. When the temperature reaches 42 to 43.5°C (108 to 110°F) death occurs. The commonly disorders experienced by Indian workers are (1) Heat exhaustion and collapse (2) Water depletion, heat exhaustion and heat cramps (at times).

Accident rate in hot environment was double than that under comfortable climatic conditions. The contributing factor according to Stephen Altman (1976) was lowered physical performance.

Thus temperature exceeding thermal limits cause discomfort, annoyance, agony and frequency of errors and accidents ultimately resulting in poor productivity.

Other Factors affecting ability to withstand high temperatures are (1) Fatigue and lack of sleep (2) Worry, frustration and nervousness (3) Smoke from cigarettes, dust, gas etc. and (4) Disagreeable odour

5.3 Heat and Cold Stress and their Indices:

Attempts have been made in past to evaluate the total heat stress limits (Tolerance or Threshold limits) by integrating some climatic and non-climatic factors which affect heat exchange between the man and surrounding environment. Heat Stress Index (HSI) can be calculated or obtained from charts and takes into account clothing and work load. From it can be recommended duration of work and rest period. Some such indices are as follows :

(1) **Effective Temperature (ET) :** It is a sensory scale of warmth derived from the dry and wetbulb temperature (i.e. air temperature and humidity) and air velocity from standard nomogram. ET is not a temperature measurable with instruments. It is an index combining effects on a body of temperature, humidity and air movement. It is equivalent to the comfort a person generally feels (there may be exceptions) in a saturated atmosphere with the same dry bulb temperature and with a specific movement of air. A person remains equally comfortable under different conditions, provided the ET remains the same.

(2) **Corrected Effective Temperature (CET) :** It is a modified ET considering the radiant temperature measured by glob thermometer instead of drybulb temperature. It does not include metabolic heat.

Considering lower body weight of Indians, ET and CET proposed by the Central Labour Institute, Bombay are as follows :

Workload	Energy Expenditure Kcal/ hr.	ET or CET ^{0}C
Light	135	32
Medium	225	29.5
Heavy	315	29

(3) **Wet Bulb Globe Temperature (WBGT) :** It embraces in a single value the effect of radiation, ambient air temperature and humidity. It is the weighted value of the wet and dry bulb temperature and globe thermometer readings, calculated using temperature measurements alone thereby eliminating the need to measure air velocity.

For outdoors (exposure to sun light) :

$$WBGT = 0.2\ t_g + 0.1\ t_{db} + 0.7\ t_{wb}$$

For indoors (no direct exposure to sun light):

$$WBGT = 0.3\ t_{db} + 0.7\ t_{wb}$$

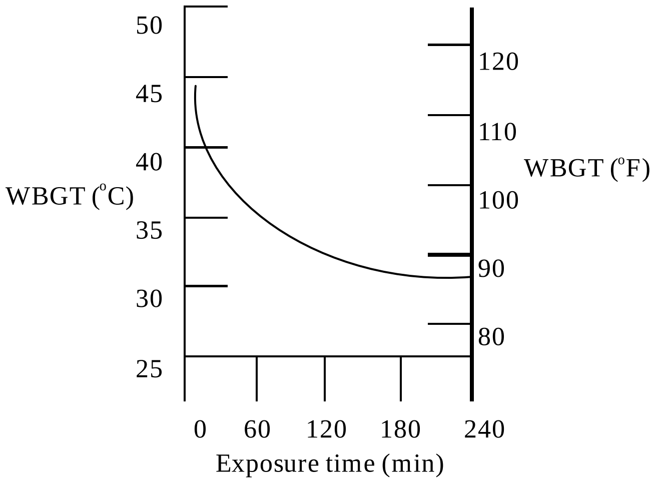
Where tg = Black Globe temperature,
tdb = Dry bulb (air) temperature and
twb = Wet bulb temperature

(°C) index is adopted by many countries to set up standards for work in hot environments. Its determination is simple and requires less expensive equipment.

It is necessary to determine the average exposure of a person over a long period of time when WBGT varied. A time-weighted average is given by : Average WBGT =

$$\frac{WBGT_1 \times t_1 + WBGT_2 \times t_2 + \ldots WBGTn \times tn}{t_1 + t_2 + \ldots tn}$$

Exposures should not exceed the values given in the following chart :



The graph shows the upper limits of exposure for feeling comfort.

Calculated time weighted or average WBGT can be compared with permissible (comfortable) level of WBGT values (°C) given in Table .10.1

This table is changed in 'ACGIH booklet 2007'. There the words ''TLV' and 'Activon Limit' are used for 'acclimatized' and 'unacclimatized' respectively. WBGT figures are slightly changed. For detail, it should be referred.

For non-cotton, non-woven clothing, overalls (double cloth) which disallow free air movements through fabric or does not absorb sweating '3 to 5' should be added to measured and calculated WBGT values which should be less then the values given in Table 10.1. These values (Table 10.1) are near the upper limit of the metabolic rate category. They are also called Screening Criteria for heat stress exposure. See Part 10 for worked examples.

(4) **Oxford Index** : This index of heat stress has been devised to assess the severity of hot humid conditions 'of the working places, particularly where the ventilation is poor. It is expressed by a simple weighting as follows :

$$WD = 0.15\ t_{db} + 0.85\ t_{wb}$$

Where WD == Weighted value, t_{db} and t_{wb} are dry and wet bulb temperature respectively. All units are in °C.

Table 10.1: WBGT -(heat stress) values in "C (ACGIH Booklet 2006.

Work demand	Acclimatized				Un-acclimatized			
	Light	Moderate	Heavy	Very heavy	Light	Moderate	Heavy	Very heavy

100% work	29.5	27.5	26		27.5	25	22.5	
75% work 25% rest	30.5	28.5	27.5		29	26.5	24.5	
50% work 50% rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% work 75% rest	32.5	31	30	29.5	31	29	28	26.5

(5) **Predicted Four Hourly Sweat Rate (P4SR):** This index is based on the assumption of the amount of sweat that would be prescribed by a physically fit and acclimatised young man in the condition under review over a period of four hours. It takes into account the metabolic level and type of clothing in addition to the climatic factors, unlike other indices mentioned earlier. But this has the drawback that cumbersome nomograms are .required which is not always practical.

(6) **Cold Stress and Wind Chill Index (WCI):** It refers to the cold environment and uses only dry bulb temperature and air velocity but takes into account the cooling effect of the wind.

In cold countries where environmental temperature goes below °C, cold stress (hypothermia or frostbite) is also possible. Body (core) temperature (rectal 37.6°C, Oral 37°C) should not fall below 35°C (95"F). Hands, feet and head are most likely to be affected by cold injury. Wind speed increases cold stress. As TLV body (core) temperature should not fall below 36°C (96.8"F).

Wind chill cooling rate is defined as heat loss from a body expressed in watts/m', which is a function of air temperature and velocity upon the exposed (area of) body. Higher wind speed and lower air temperature require higher insulation. value of the protective clothing. Exposure or working time of workers should also be reduced. Old and weak workers need such extra precaution.

Since the physical activity level on the shop floor will remain almost constant, we may make use of the simple indices like CET/ET or WBGT in our control programmes.

Heat Exposure Threshold Limit Values (USA) and Bolding Hatch Heat Stress Index (HSI) are other indices.

5.4 Health and Safety Problems in Hot and Cold Environment:

5.4.1. Problems in Hot Environment:

Types of health disorders caused by exposures to high heat are as under :

1. Skin disorders - prickly heat (miliaria rubra), skin cancer (rodent ulcer).
2. Systemic disorders - heat stroke (hyperpyrexia), heat exhaustion (circulatory deficiency, heat syncope), heat cramp (sweating deficiency), water deficiency, salt deficiency.
3. Psychoneurotic disorders - mild chronic heat fatigue, acute loss of emotional control.

These disorders can cause following effects

1. Heat or sun stroke due to excessive rise in core (body) temperature 'resulting from failure of thermo regulatory mechanism.
2. Heat Exhaustion due to loss of body fluid (with salt) in sweating.
3. Heat or muscle cramps due to profuse sweating and salt loss, drinking much water and failure to replace body's salt loss.
4. Fainting due to more blood in the skin and lower part of the body, less return to the heart for pumping to the brain.

5. Heat Rush or Prickly Heat likely to occur in hot and humid environment where sweat is not easily removed from the skin surface and sweat glands plugged.
6. Transient heat fatigue due to prolonged heat exposure.

Safety Problems are : Accidents due to sweating palms, dizziness, forging of safety glasses, contact with hot surface, molten metal, steam etc., and physical discomfort and fatigue.

Other safety problems due to increased temperatures are:

1. Increase in corrosion rate.
2. Increase in pressure in a confined space.
3. Decrease in reliability of electronic devices.
4. Decomposition of liquids generating contaminants that may plug orifices so equipment fails.
5. Burns to personnel and reduction in their efficiency.
6. Fire and explosion. Liquid expansion & overflow.
7. Melting of metals and thermoplastics. Loss of ductility and effects on metals.
8. Weakening of soldered seams.
9. Distortion of warping of parts.
10. Peeling of finishes, blistering of paint.
11. Decreased viscosity of lubricants.
12. Increased evaporation and leakage of liquids (fuels, lubricants, toxic liquids).
13. Increased reactivity, gas diffusion etc.
14. Breakdown of chemical compounds.
15. Increased electrical resistance and opening or closing of electrical contacts due to expansion.

The Causes of temperature rise are also many and include generation or absorption of heat from - fire or explosion, electrical heating, solar heating, friction, spark, gas compression, hot weather, hot working of metal, nuclear reaction, exothermic chemical reaction, lack of insulation from thermal sources, failure of cooling system, poor heat dissipation capacity, biological, physiological or organic decay processes.

Similarly there are hazards of low temperature also.

5.4.2 Problems in Cold Environment:

Adverse effects of cold stress are. mental dullness, poor decision making and loss of consciousness (at 32 to 30°C body temp.) As protections, insulating dry clothing (e.g. woollen sweaters, mufflers, coat etc) must be provided to workers, if they have to work below the atmospheric temp. 4°C (40°F).

Local tissue freezing may occur at temp <- 1°C (32.2°F) irrespective of wind speed. At air temp = 2°C (35.6°F), wet clothing should be immediately changed. As wind speed increases or/and air temp decreases, number of breaks should be increased and work period should be decreased.

Control measures increase with decrease in temperature as under -

To work below	Protection includes
16°C (60.8°F)	Warm air jets, radiant heaters; contact • with warm plates.
-1°C (30.2°F)	Tool handles and control bars should have thermal insulation.
-7°C (19.4°F)	Warning for not contacting by bare skin. Warming shelters like tents, cabins, rest rooms should be provided nearby.
-17.5°C (0°F)	Mittens for hand protection.

Chilled wind should be diverted or obstructed by partitions or shielding. Contact of evaporative (low boiling) liquid should be avoided otherwise chilling effect will increase by evaporative cooling.

Such protections are hardly required in our country due to moderate temperature.

5.5 Control of Heat Stress:

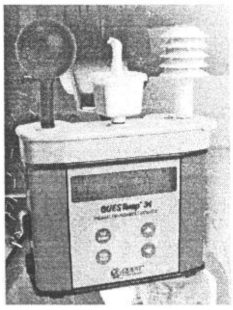


Fig. 10.7 Portable Heat Stress Monitor

Heat stress should be measured to find appropriate control measure. Heat stress monitors with or without air probe are available and they are useful for area heat stress monitoring. Personal heat stress monitor with sensor is available for personal heat stress monitoring.

Fig. 10.8 Personal Heat Stress Monitor

How to control atmospheric conditions so that varying effects on workers can be reduced to a minimum is a good task for safety engineers. The remedies varying from plant to plant should be determined from the specific study of the plant (including workers) itself. Ventilating system which moves and filters the air and which controls the temperature and humidity is a good control. Various engineering, administrative, statutory and personal protective controls can be applied to minimise heat stresses. Methods of engineering control and personnel management are given below:

5.5.1 Methods of Engineering Controls :

Refer heat balance equation in part 5.1. Then to control the effects of parameters M, C, R & E following control measures are necessary :

To reduce heat of metabolism i.e. gain by M - Reduce level of physical activity by sharing work load with others or by using mechanical means. Schedule cooler periods for work. Increase rest periods.

To reduce high air temperature i.e. gain by C - Insulate hot equipment. Provide canopies with fans over hot equipment to drive away hot air. Improve general and localised ventilation over personnel. Provide exhaust ventilation, local cooling, evaporative cooling, refrigeration, isolation, substitution, relocation and redesign as per need. Use ventilated suits against excessive heat.

To reduce radiation temperature, i.e. gain by R - Insulate hot 'equipment. Use reflective or absorptive shielding between the heat source and man. Paint the surface of hot equipment or shield or clothe it by using white colour for short wave of solar radiation and aluminium colour for infra red radiation. Wear protective clothing of reflective surface of polished metal or paint or ventilated suits. Interpose line of sight barrier. Cover exposed parts of the body. Use fans to move air and exhaust ventilation.

To reduce high humidity (restriction on loss by E) - Prevent steam leaks. Improve general ventilation. Apply dehumidification in confined spaces. Use ventilated suits for high humidity. Decrease humidity and increase air speed.

5.5.2 Methods of Personnel Management (Administrative efforts):

1. Provide ample supplies of cool water or flavoured drinks.
2. Provide extra salt where required.
3. Ensure lightweight, loose fitting clothing. In conditions with no radiant heat load, use as little clothing as possible. With high radiant heat loads, clothing should cover skin; where possible, clothing should be of cotton and white.

4. Ensure quickest development of acclimatisation. Lack of salt, lack of water or poor physical condition retards acclimatisation.
5. Where possible do not employ men in hot conditions if they are : obese, suffering from any cardiovascular disease, suffering from or recovering from febrile illness, over 45 years of. age, physically unfit and suffering from any skin disease or if they fail to sweat properly.
6. Where possible, arrange for men who are to work in hot surroundings to spend their first two weeks working in cool surroundings in the morning and in the heat in the afternoon. (This - will help acclimatisation)
7. Analyse Working situations for estimation of heat load through various channels. Apply physical methods to control hazard; if necessary amplify by control of work and rest routine.
8. Rest periods should be taken in cool surroundings. Men may effectively 'cool off even when they continue to work in cool conditions.
9. In extreme conditions man may : wear ventilated suits, be pre-cooled by immersion in cool water and be cooled down by spraying them with cool water.
10. Train in first-aid for heat strain symptoms.
11. Pre-employment and periodic medical examinations for proper placement of individuals considering their age, sex and physical fitness and
12. Observation of individual physiological responses to heat and to change their job or place if necessary.

Acclimatisation is an important factor for a worker to work for a long period in hot environment. Acclimatisation means the habit by which a person adapts himself to living and working in a hot and humid atmosphere. It is manifested as a reduction in the heart rate and internal body temperature at the expense of increased sweating.

The factors affecting physiology of acclimatisation are (1) Process of thermal regulation (2) Cardiac output and heart rate (3) Sweating.

Sweating starts when the skin temperature exceeds 33 °C. There are some 25 lacs sweat glands in a body of 70 kg man. During the period of acclimatisation, the sweating rate may rise from 1.5 lit/ h to 3.5 lit/h. The maintenance of a body temperature 37 °C is achieved by constant adjustment of the process of thermogenesis and thermolysis. An acclimatised person should not lose more than I lit/h and the rectal temperature should not exceed 38 °C.

The following factors help acclimatisation to high temperatures:

1. Persons having less than 50 kg body weight, more than 45 years of age and maximum oxygen consumption less than 2.5 lit/min should not be selected. Females get difficult to acclimatise.

2. Liquids should be taken in small quantities and often from the start of exposure to high temperatures.

3. The intake of fatty foodstuffs should be reduced.

4. Small doses of vitamins B and C are supplementary.

5. Work breaks during shift should be increased. During rest cold drinks reduce stress.

6. Heat resisting barriers which include insulation over the heat source, polished reflectant shields, absorbent shields (being cooled by air or water) and personal protective equipment (e.g. water jacketed clothing).

5.5.3 Statutory Requirements :

See Part 2 and 6.4 for statutory requirements to control heat stress.

6 GENERAL CONSIDERATIONS FORVENTILATION

6.1 Definitions :

Following definitions are useful to understand ventilation systems:

Micron: A unit of length, the thousandth part of I mm or the millionth of a meter (approximately l/ 25,000 of an inch).

Aerosol: An assemblage of small particles, solid or liquid, suspended in air. The diameter of the particles may vary from 100 microns down to 0.01 micron or less, e.g., dust, fog, smoke.

Mists: Small droplets of materials those are ordinarily liquid at normal temperature and pressure.

Vapor: The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states either by increasing the pressure or decreasing the temperature.

Dust: Small solid particles created by the breaking up of larger particles by processes like crushing, grinding, drilling, explosions, etc. Dust particles already in existence in a mixture of materials may escape into the air through such operations, as shoveling, conveying, screening, sweeping, etc.

Fumes: Small, solid particles formed by the condensation of vapors of solid materials.

Gases: Formless fluids which tend to occupy an entire space uniformly at ordinary temperatures and pressures.

Air Cleaner: A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapors, fumes, and smoke. (Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters.)

Comfort Zone (Average): The range of effective temperatures over which the majority (50% or more) of adults feel comfortable.

Dust Collector: An air cleaning device to remove heavy particulate loadings from exhaust systems before discharge to outdoors. Usual range: loadings 0.003 grains per cubic foot and higher.

Entry Loss: Loss in pressure caused by air flowing .into a duct or hood (inches HO).

Hood: A shaped inlet designed to capture contaminated air and conduct it into the exhaust duct system.

Capture Velocity: Air velocity at any point in front of the exhaust hood necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the exhaust hood.

Manometer: An instrument for measuring pressure; essentially a U-tube -partially filled with a liquid, usually water, mercury or a light oil, so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Minimum Design Duct Velocity: Minimum air velocity required to move the particulates in the air stream, fpm.

Plenum: Pressure equalizing chamber.

Natural Ventilation: Supply of outside air into a building through windows or other openings due to wind outside and convection effects arising from temperature or pressure differences (or both) between inside and outside of the building.

General Ventilation: Supply of outside air either by positive ventilation or by infiltration into the building.

Positive Ventilation: Supply of outside air by mechanical device, such as a fan.

Dilution Ventilation: Supply of outside air to reduce the air-borne contaminants in the building. It may be due to natural or mechanical ventilation.

Exhaust of Air: Removal of air from a building and its disposal outside by mechanical device such as a fan.

Mechanical Ventilation: Supply of outside air either by positive ventilation or by exhaust of air (causing reduction of pressure inside), or by their combination.

Local Exhaust Ventilation: Ventilation effected by exhaust of air through an exhaust appliance, such as hood with or without fan located as closely as possible to the origin of contaminants so as to capture effectively the contaminants and convey them through ducts to a safe point of discharge (e.g. dust collector, scrubber, flare etc.).

Dry Bulb Temperature: The temperature of the air read on a thermometer, placed in such a way as to avoid errors due to radiation.

Wet Bulb Temperature: The steady temperature finally given by a thermometer having its bulb covered with gauze or muslin moistened with distilled water and placed in an air stream of not less than 4.5 m/s.

Humidity Absolute: The weight of water vapour per unit volume, lb/ft" or g/cm"

Humidity Relative: The ratio of the actual partial pressure of the water vapour in a space to the saturation pressure of pure water at the same temperature.

Humidification: The process whereby the absolute humidity of the air in a building is maintained at a higher level than that of outside air/or at a level higher than that which would prevail/naturally.

Due Point: When the temperature of a saturated space is reduced, more moisture will condense than evaporate until equilibrium is again reached. The temperature at which saturation occurs and condensation begins is the due point or saturation temperature.

Spray-head System: A system of atomising water so as to introduce the moisture directly into a building.

Make Up Air: Outside air supplied into a building to replace the air removed.

Air Change per Hour: Ratio of the outside air volume allowed into a room in one hour to the room volume. .

6.2 Air Requirement:

Before studying the types of ventilation, it will be useful to know about the required air composition and air movement. It is given table 10.2 :

Table 10.2: Air Composition (Percentage Volume)

Component	Outdoor air Dry	Indoor air 20 °C RH 50	Expired air 36 °C RH 100
Oxygen	20.97	20.69	16
Carbon dioxide	0.03	0.06	4
Water vapour	0.00	1.25	5
Inert gases (Nitrogen Argon etc.)	79.00	78.00	75
	100.00	100.00	100

Thus ventilation is necessary for not allowing the air components to reach their expiry limits. Minimum six air changes per hour are necessary in a workroom.

A person working hard, breaths about 40 litres of air per minute, consumes about 2 litres of oxygen and exhales about 1.7 litres of carbon dioxide. A sleeping person consumes only about 1/10 of this amount. Air movement below 0.075 m/s gives feeling of stagnation and above 0.4 m/s a perceptible draft. Its comfortable range is O.I to 0.3 m/s. :

Fresh air supplies oxygen to the human body. Normal air requirement is 20 m" to 30 I113 per person per hour. Fresh air supply and movement reduces heal stress by dissipating heat from body by evaporation of the sweat when relative humidity is high and the au temperature is below or near body temperature.

If sensible heat H in Kcal/h (i.e. heat due to sun, process emission and exhaust of occupants) and allowable temperature t in °C are known, the volume of outside air Q in "/h, required to remove the sensible heat is given by -

$$Q = \frac{3.462 \times H}{t}$$

6.3 Control Criteria :

In addition to the composition, amount, temperature and movement of air, the airborne contaminants including dust, gas etc., also need to be controlled.

Mechanical ventilation becomes necessary to prevent their concentration. Toxicity, rate of generation, concentration, exposure time and workers' susceptibility should be considered while controlling air borne contaminants by ventilation. Elimination of dangerous materials creating contaminants, reducing its concentration by dilution ventilation and preventing its accumulation by removing the contaminants at its point of origin by local exhaust ventilation and isolating the process in a sealed system (preferably under vacuum) are most important engineering factors to be considered while designing appropriate ventilation system. Use of respiratory protection, good housekeeping and training are additional complementary factors.

Generally two streams (jets) are important, those containing hot or contaminated air from machines or processes and those containing fresh air from openings or ventilation grills. Their mixing causes dispersion and dilution. Their rates should not be excessive. Draughts of fresh or cool air also cause discomfort. Exhaust hoods must be placed very close to a source of heat or contaminant to prevent their escape in surrounding.

Air cleaning devices are used to remove contaminants from the air or .gas stream. They are available in a wide range of varieties. Their selection criteria are:

1. Particle size and concentration of contaminant.
2. Characteristics of the air or gas stream.
3. Characteristics of the contaminant.
4. Degree of collection required, and
5. Method of disposal.

The equipment works on following principles:

1. Gravity forces.
2. Centrifugal forces.
3. Electrostatic forces.
4. Scrubbing, and
5. Impactiation.

Equipment available are of the types : Settling chambers, 'Gravity traps, Rotoclone, Cyclone separator, Multicyclones, Wet cyclone. Fabric filters. Electrostatic precipitators and Scrubbers.

6.4 Some Design Factors :

The main objects of ventilation design are to supply fresh air for respiration, to dilute air to prevent ventilation by body odours, to remove any contaminants in air, and to provide such thermal environment to maintain heat balance of the body in order to prevent discomfort and injury to health of the occupants. For this purpose it may be necessary to either decrease (cooling) or increase (heating) the workroom temperature, to control the humidity and to regulate the rate of air movement. Thus industrial ventilation is an integral part of air conditioning when it is used in combination with heating, cooling and humidifying appliances to maintain satisfactory condition for the product or the occupants.

Ventilation is useful for heat and contaminant controls and is accomplished by air stirring or supplying fresh air or removing unwanted air or by their combination. Where flammable gases are used or emitted, the ventilation is needed to keep the atmosphere safe from ignition. Electric fittings should be flameproof.

The supply openings i.e. inlets into the room should be located near the occupants if possible and opposite to that should be the air-return openings. The supply outlets should also be directed towards or over the occupants so that air moves from the fresh air supply in the direction of the occupants and then out of the returns and exhaust hoods.

The amount of ventilation required depends on:

1. Size (including height) and type of room and its usage.

2. Duration and type of occupants and their activities.
3. Heat gains from sun, hot processes, machinery, electrical equipment and occupants.
4. Comfort conditions required inside the room.
5. The operation of the ventilation system.

Generally 20 to 30 m" air per person per hour, at least 6 air changes per hour and 14 to 16 m3 space (limited to the workroom height 4.25 m) per worker are recommended for ventilation where there are no contaminants to be removed from air. Excess heat from a hot environment has to be offset to maintain normal body temperature 37 °C. Normal energy expenditure in moderate work by a man is 235 to 330 Kcal/h for which maximum wet bulb temperature shall not exceed 29 °C and air movement (velocity) of more than 30 m/min shall be necessary.

Rule ISA of the Gujarat Factories Rules (GFR) requires that -

1. Wet bulb temperature in a workroom should not exceed 30 °C (thermometer htl.5 mt).
2. Air movement should not be less than 30 m/main
3. Dry and wet bulb temperature should be as under –

Dry Bulb Temp (°C)	Wet Bulb Temp (°C)
30 to 34	29
35 to 39	28.5
40 to 44	28
45 to 49	27.5

4. Ventilating openings (D, W & V) in a workroom should be more than 15% of the floor area and so located as to afford a continued supply of fresh air at workers' level.

5. Quantity of fresh air supply by mechanical means should be six times the workroom volume (m') per hour. It should be evenly distributed in the' workroom.

6. In summer when temperature exceeds 35 °C and humidity more than 50% permissible in the workroom, desert coolers or central air washing plant can be suggested by the Inspector.

7. Above limits are not applicable where artificial humidification (Sec. 15 of the Factories Act), refrigeration or high process temperature are applicable.

Generally more than 60 m/min air velocity shall be avoided unless the temperature and humidity are high. In case of heavy manual work, if the air is capable of absorbing heat from the body, an air-blast up to 300 m/min may be directed at the workers for velocity and evaporative cooling. Capture velocities (0.25 to 10 m/s) for local exhaust ventilation for contaminants control are given in Table-3 of IS:3103. The rate of air flow in the duct or grille shall be within 10% of the amount required and variation of air flow through filters and grilles shall not exceed ± 20% of the mean value.

The dry and wet bulb temperatures shall be maintained as per the schedule given by the Factories Rules or IS:3103. In case of industrial building wider than 30 m, the ventilation may be augmented by roof ventilation. Ventilation rates of 30 to 60 m3/h/ 2 of floor area have been found satisfactory. Where the desired temperatures and humidity cannot be obtained by mere ventilation, air conditioning may be resorted to as per IS:659 and 660.

7 TYPES OF VENTILATION

7.1 Classification of Ventilation Systems :

For better grasping, major ventilation systems are classified as below :

Ventilation Systems

- Natural Ventilation
  1. Dilution or Cross ventilation (Wind action)
  2. Roofed ventilation (Stack action)
- Mechanical Ventilation
  - (A) For Building
    1. Exhaust or Negative Ventilation (Induced draft)
    2. Plenum or Positive Ventilation (Forced Draft)
    3. Combined or Compound Ventilation
    4. Roof Ventilation
    5. Comfort Ventilation (Air Conditioning)
       - (a) Refrigeration
       - (b) Heating
       - (c) Humidity Control or Evaporative Cooling
  - (B) For Contaminants Control
    1. Dilution or forced Ventilation
    2. Local Exhaust or Extract Ventilation
    3. Emergency Ventilation

Ventilation systems are of two types (1) Supply air system and (2) Exhaust system. Supply air system has two purposes (A) heating, ventilating and air conditioning (HVAC) for comfortable environment and (B) to replace exhausted air from the plant. Exhaust system is of two types: General and Local exhaust type. General exhaust system is for heat control and/or removal of contaminant by dilution ventilation and Local exhaust system is for capturing contaminant at source.

The details of these varieties of ventilation and calculation methods occupy much space. Their design is a specialised job for ventilating engineers. Here they "are explained in brief as follows.

7.2 Natural Ventilation :

Natural ventilation is induced because of two reasons (1) outside wind pressure i.e, wind action and (2) temperature difference of the air inside and outside the room i.e. chimney effect. There is a positive pressure on windward side and negative pressure on leeward side. By providing adequate openings in these pressure areas, natural ventilation can be achieved.

The rate of ventilation by natural means through windows or other openings depends on direction and velocity .of wind outside, solar radiation, size and disposition of opening (wind action), convection currents arising from temperature or vapour pressure difference (or both) between inside and outside the room and the difference of height between the outlet and inlet openings (stack effect). They are of two types as under

(1) Dilution or Cross Ventilation: Inlet openings should be located on the windward side at a low level and outlet openings should be located on the leeward side near to the top so that incoming air stream is passed over the occupants. Greatest flow per unit area opening is obtained by using inlet and outlet openings of nearly equal areas. Under the Factories Rules ventilation opening area in a work room shall be at least 15% of the floor area. At least 10% of the floor area shall be located at not more than one meter sill level height from the floor level. Wind velocity in hot weaver should be 40 to 60 mt/min. Ventilation due to wind outside is given by the formula Q = kAV given in Part-9.

Inlet openings should not be obstructed by surrounding buildings, walls, partitions, trees and other obstructions in air path. Great advantage is available by providing windows in west and east direction. However if wind direction is not effectively available, openings in all four sides can help the natural ventilation.

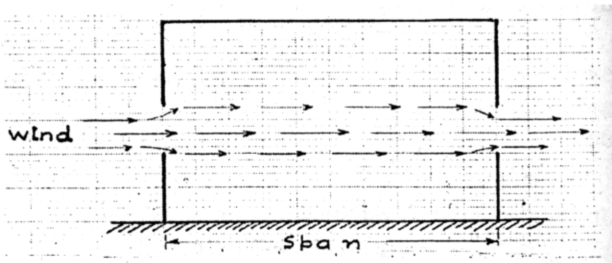


Fig. 10.9 With flat roof, cross ventilation is effective when span is less than 20 meters.

When the room temperature is higher than that of outside because of hot processes, season etc., cool outside air tends to enter through openings at low level and warm air tends to leave through openings at high level. Therefore it would be advantageous to provide ventilators near to the ceilings.

(2) Roofed Ventilation : Cross ventilation suitable for narrow building is not much suitable for large buildings and where roofed ventilation is suitable. Here ventilators are provided in roofs viz. cowl, vent pipe, covered roof and ridge vent to give stack effect.

For a 60 cm (24 in) diameter cowl type ventilator the formula's -

$Q= A (8 \sqrt{H(t_i-t_0)}+5.82V)$

Where Q = capacity of the ventilator in m3/min, A = cross sectional area of the ventilator in 2 H = height of the ventilator above the inlets in m, t. and t are the inside and outside temperatures in °C and V = wind velocity in kmph.

See fig. 10.10 for different types of roof and fig. 10.11 for modified roof ventilation.

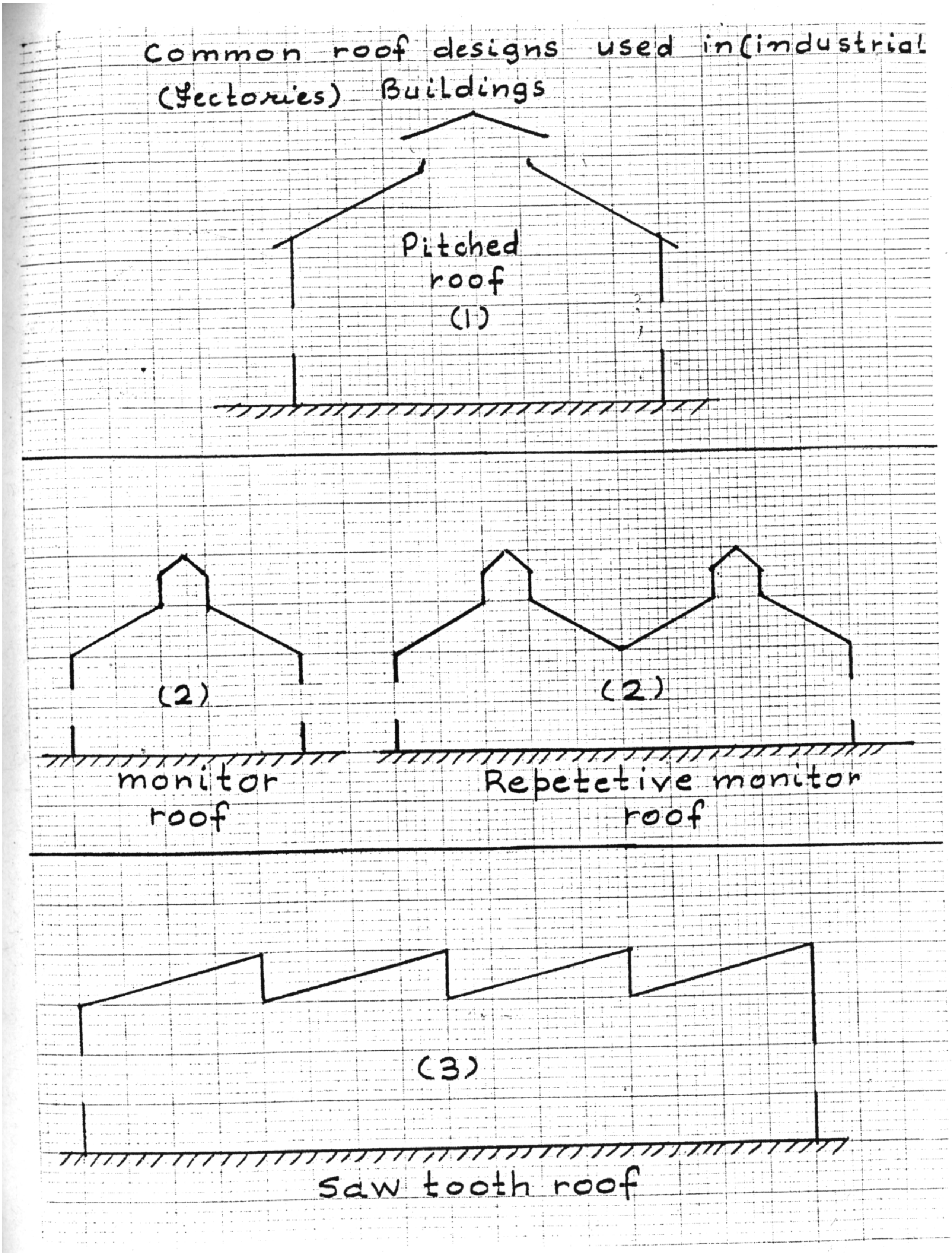


Fig. 10.10 : Types of roof for natural ventilation,.

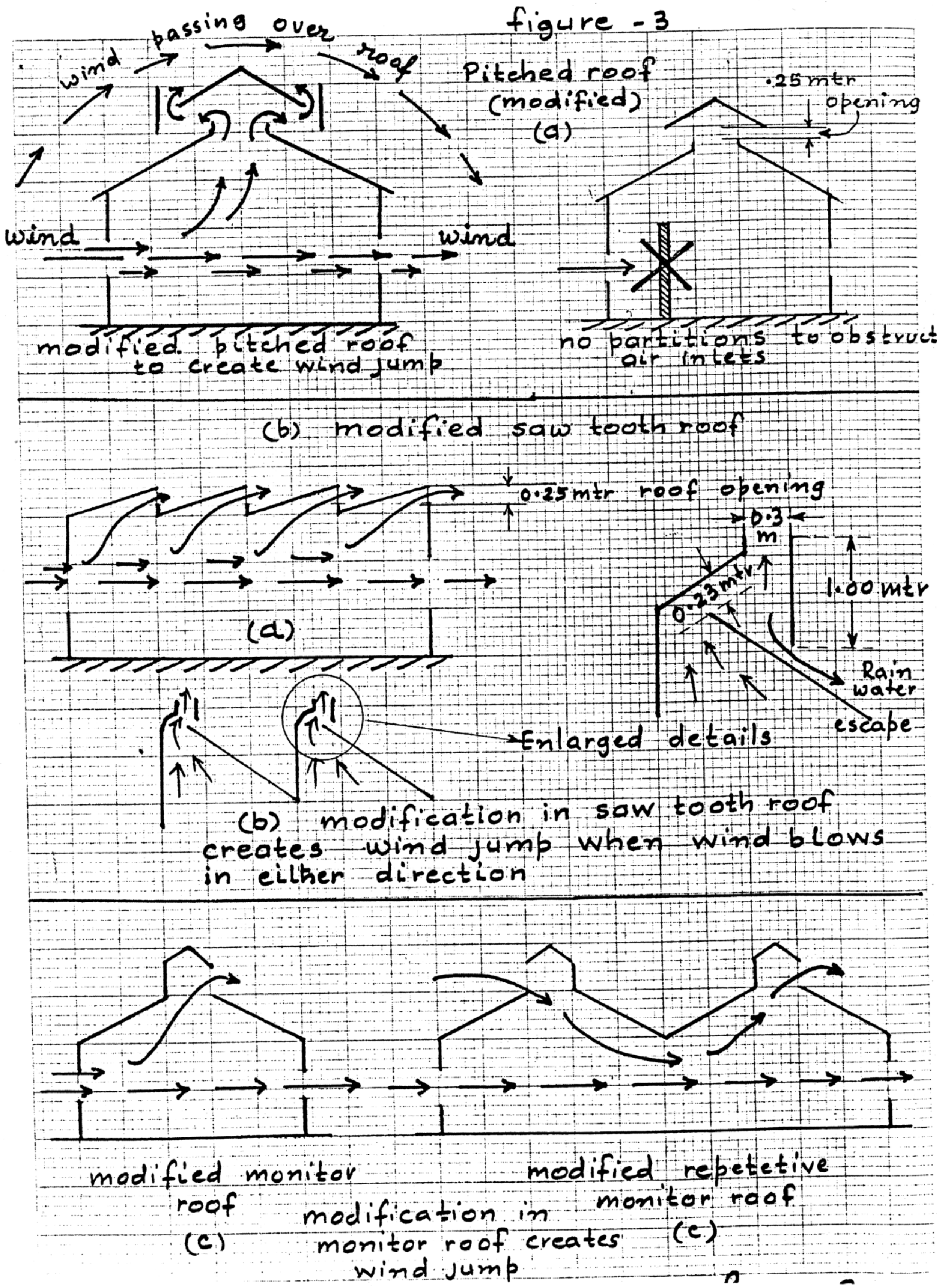
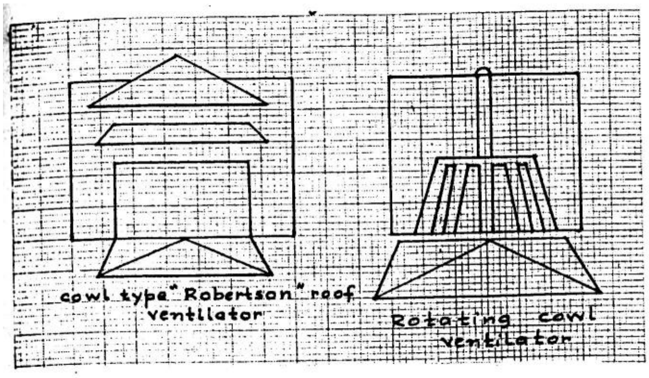


Fig. 10.11 : Modified pitched roof and monitor roof.

In roofed ventilation, natural ventilation is used by chinmey (stack) effect due to temperature difference. This effect is counteracted by wind blows straight against roof openings. By suitable design of itched roof, saw-tooth roof or monitor roof this interference can be reduced.

Cowl type Roof Ventilation : Fixed or rotating owl (hood on roof vent) is provided to accelerate natural roofed ventilation. The performance of roof cowls depends on temperature difference between inside and outside air, velocity of incoming wind, cross sectional area of the ventilator and its height above air inlet. For a 60 cm (2 ft) diameter cowl, air flow capacity is given by the formula stated above.



Rotating cowl requires a lubricant reservoir for its long service to run without jamming.

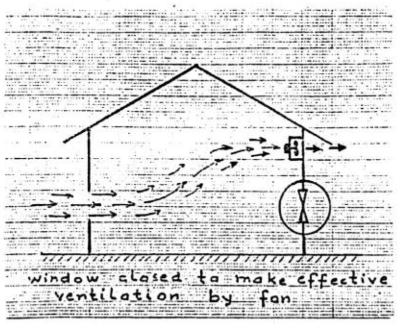
7.3 Mechanical Ventilation :

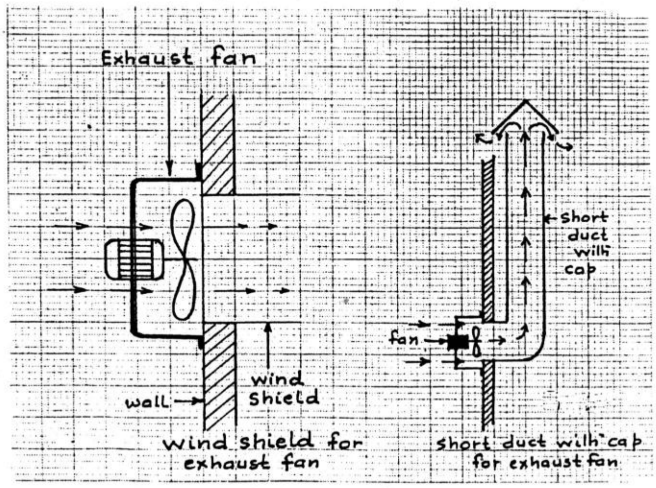
Mechanical ventilation is employed for building i.e. workroom and also for process for removal of contaminants. Both the types are explained below.

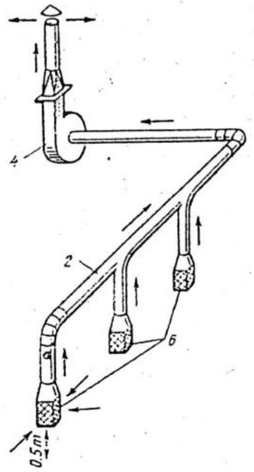
7.3.1 Building Ventilation:

These are of many types as classified earlier. When natural ventilation is not sufficient to keep thermal environment within the limits specified by dry and wet-bulb schedule under the Factories Rules, or where the span of work room exceeds 18 meters or where any work place is more than 9 meters away from a ventilation opening, mechanical ventilation (exhaust, positive or their combination) shall be provided and in case of positive ventilation, air shall be cleaned and cooled before sending into the work room.

(1) **Exhaust or Negative Ventilation:** Exhauster induced draft fans are provided in walls on one side of the building or in the attic and roofs to draw large volumes of air through building. These fans are generally propeller type. The windows and other openings near the fans should be kept closed to avoid 'short circulating of air'. Adequate inlet openings shall be provided on opposite side of the building to limit inlet velocities. When fans are centrally located on an attic or arranged to draw from exhaust appliances with ducting, they should be centrifugal or axial types to overcome duct resistance. The total inlet area should be at least 3 times the total disc area of the fan.







The exhaust fans should have wind shields on outside of the wall so that wind pressure may not decrease their efficiency. The fans discharge should be diverted into large ducts carried vertically upwards with rain water cap at the top. Fans should have proper guarding or fencing.

(2) Plenum or Positive Ventilation : It is provided by centrally located supply fans (generally centrifugal type) having a wide range of capacity and quiet operation. Air-tight ducts increase the advantage. Unit ventilators should be provided for individual rooms and may be placed against outside wall near the central line of the room. Evaporative cooling coils can be incorporated for cooling purpose.

Plenum ventilation is useful for large workrooms where exhaust ventilation is normally not effective. Its air movement and regulation are more than that by exhaust ventilation. Better dilution of contamination is also possible. The air velocities should not be excessive to disturb manufacturing processes. Good distribution can be achieved by using diffusers or swivel type ejector nozzles at high velocity at the inlets. For positive ventilation, the volume of air is given by Q = AV, where Q = air volume in m''/ in, A = free area of intake openings of ducts in m' and V= average velocity of air in m/min.

The positive air pressure inside the room disallows outside hot or cold air leakage inside.' Better dilution is achieved. Ducts should be smooth, straight, with minimum bends and without sudden enlargements or contractions. The air velocity should not be too excessive to interfere with the manufacturing process or be unpleasant. Discharge nozzles should discharge air horizontally at a height little above the heads of the workers. Air velocity in a duct should be @10 m/s for gases and @20 m/s for particulates.

(3) Combined (Compound) Ventilation : It is the combination of positive and negative (exhaust) ventilation with the advantage of better air distribution over the entire area of a large building. By supplying proper volumes of air at suitable velocities at the required areas through duct and by extracting the air in the return duct and re-circulating this air after proper cleaning and mixing it with cool fresh air, good results can be obtained. It is preferable to provide slight excess of exhaust if there are adjoining occupied spaces and a slight excess of supply if there are no such spaces. Unit exhausters can be used to match with unit ventilators exteriors and located along the outside wall.

(4) Mechanical Roof Ventilation : It is used for augmenting natural ventilation in buildings with large width (>30 m) or where the heat load is very heavy. Exhaust fans exercise very little influence beyond a velocity contour at about 15 m/min which is a short distance from the fan. The volume of air required in removal of sensible heat gained (in Kcal/hr) can be calculated from the formula -

$$Q = \frac{\text{Kcal/hr} \times 3.462}{\text{Temperature rise in } ^\circ\text{C}}$$

where Q is the volume of air in m^3/hr, and allowable temperature rise = Inlet opening temp. Outside temp., is given by following approximate figures.

Roof elevation in mt	Rise in °C
6	3 to 4.5
9	4.5 to 6.5
12	6.5 to 11

These values are at roof exit and not the floor temperatures. The maximum allowable temperature rise for an air stream as it leaves the grills and reaches the working level is 1.7 to 2.8 °C (5 °F).

(5) Comfort Ventilation: It is the method by which the interior of a room is heated or cooled or the humidity altered for process control or comfort conditions.

As refrigeration is very expensive, evaporative cooling may be adopted with advantage where summers are dry with low wet bulb temperatures. The quantity of air required for ventilation could be reduced if the outside air is cooled before the air is discharged into the building. Although the relative humidity of supply air will be increased but due to the large sensible heat loads, the resultant relative humidity in the workroom will be lowered after mixing with the inside air to produce body cooling.

Water spray chamber and a fan to supply outside air into the workroom through a distribution duct is preferable to spray which only humidifies the air where the cooling capacity of the air is not much improved and no hot air is removed from the building.

Evaporative cooling is generally used in cotton textile mills where humidification is necessary to meet the process conditions. It can also be used in chemical plants (where water is not reactive), non-ferrous casting shops, tobacco factories etc. It is useful in rubber factory to prevent static electricity due to solvent and in printing or lithographic works to maintain paper size. It is suitable where dry bulb temperature is 35 °C (95 °C) or more, wet bulb temperature 25 °C (67 °F) or less and relative humidity 5% or more during 15th March to 15th July as required under Rule 18A(3) of the Gujarat Factories Rules.

The spray chamber (air washers) and single or multi bank up or down spray system can be designed after careful considerations. Make-up water in circulation (about 1.5 to 2%) can be calculated from evaporation losses, bleed off losses and driftage. For safety in air-conditioning and mechanical refrigeration, IS:659 and 660 shall be referred respectively.

See Part 7.5 for air-conditioning.

7.3.2 Process Ventilation (Contaminants Control):

Mechanical ventilation is also employed for contaminants control as follows :

(1) Dilution or Forced Ventilation : It is helpful in reducing contaminant concentration in work area to control health and fire hazards. This is useful to control less toxic vapours such as from organic solvents. It is not useful to control fumes, dusts and contaminants of high toxicity (TLV less than 100 ppm) and high quantity or concentration. It is also not useful where pollutants are released intermittently. The amount of air required for dilution can be calculated from the following formula:

Air required for dilution in m^3/kg of evaporation or generation of gas

$$= \frac{24 \times 10^6 \times F}{\text{Molecular weight of toxic gas} \times \text{TLV in ppm of liquid or gas}}$$

Where F is a factor of safety for health hazard varying from 3 to 10 and depending on the - toxicity, evolution rate of contaminant and effectiveness of the ventilation.

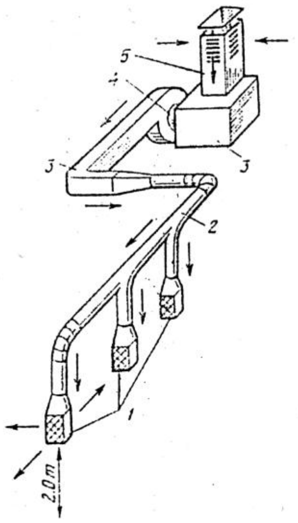
The formula for control of fire hazard is as follows:

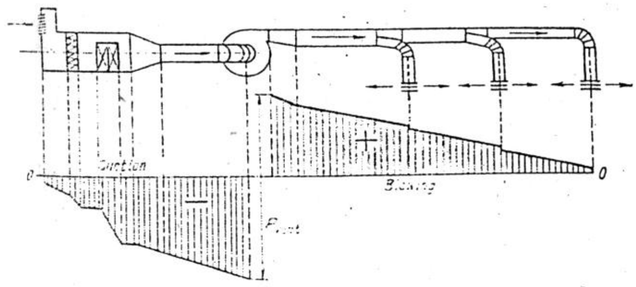
Air required for dilution in m^3/kg of flammable gas.

$$= \frac{24 \times 100 \times F}{\text{Molecular weight of the gas} \times \text{LEL} \times C}$$

Where F is a factor of safety for fire hazard varying from 4 to 12 depending upon the percentage of LEL (Lower Explosive Limit) and C is a constant which is 1 for temperatures up to 121 °C and 0.7 for temperatures above 121 °C.

Normally this method is adopted where it is impossible to fit an extractor to the work point. Hourly air changes in a work room are for dilution purpose. It should be 6 times the room volume per hour.





The air flow volume to be provided should take into account (1) the volume of the pollutants released (2) the concentration permitted in the workplace and (3) a factor of safety which allows for the layout of the room, the airflow patterns created by the ventilation system, the toxicity of the pollutant and the steadiness of its release.

(2) Local Exhaust or Extract Ventilation : It is applied at the release points of contaminants (dust, gas, fumes, particles etc.) to reduce their concentration in the workroom below TLVs. Su(;h points shall be enclosed except where access is necessary for the process, but in that case, the exhaust appliance shall confine the contaminants as much as possible.

The volume of air required is calculated from the area of openings and the capture velocity sufficient to prevent outward escapement. The sizes of the ducts shall be calculated from the volume of air required and duct velocities necessary to convey the contaminants with minimum static resistance.

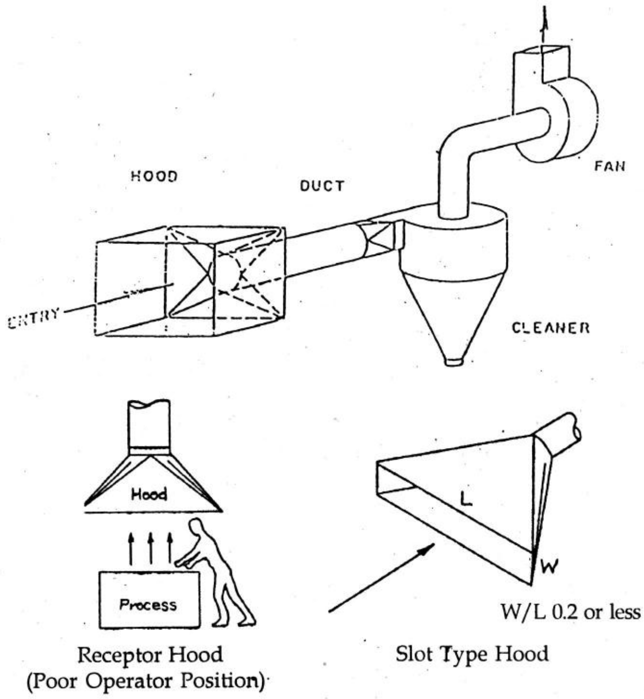


Fig. 10.12 Elements of a local exhaust System

Capture velocities may vary from 0.25 to 10 m/ s proportionately increasing with the contaminants velocity as given in Table-10.3. The test report for dust/ fume extraction system shall be in form No. 26A under the Gujarat Factories Rules.

Where the emissions of heat or contaminants are high, dilution ventilation is not fully effective and the well designed exhaust ventilation becomes necessary."

Exhausted air may be re-circulated after cleaning and filtering to increase the rate of mechanical ventilation.

Hood, duct, air cleaning device, filter or collector (to separate contaminant from the air before discharging it into atmosphere) and fan and motor (for air flow) shall be designed or selected properly.

Hoods are of many types - booth, canopy, side draft, cabinet, single or double lip and push and pull type

Duct may be square or rectangular, with material to resist abrasive or corrosive action. Sharp corners shall be avoided. Cleaning and trapping gates shall be provided. Generally the conveying velocity may be from 10 to 25 m/s depending upon the type of contaminant and balancing of equal flow rate of air.

Types of air-cleaners, dust separators or collectors are settling chambers, cyclones, dry dynamic precipitators, scrubbers, wet collectors, electrostatic precipitators, fabric filters and air cleaners for gases and vapours. The fan selection depends upon air volume and static pressure required. A guide for selection of collectors is given as Table-18 in Chapter-32.

Points to be considered while **designing a hood** are :

1. Enclose the operation as much as possible. Hood should be as near as possible to the source of generation. Doubling the distance require approximately four times the air volume.
2. Hood should be so located as to keep the flow of contaminants away from the worker.
3. Hood should be so placed as to take advantage of initial velocity and direction of the throw of the contaminant. For example, lighter vapour, hot substances, gas tending to rise, should be collected by hood overhead, while heavier particles or gas/ vapour with vapour density > I and tending to settle, should be collected by placing hood down or at the side.
4. Hood should not interfere the movement of the operator and the job.
5. Portable power drills, grinders, saws etc. should have machine attached extractor and dust collection chamber to be carried on back or on wheels to suck the particles flying at the point of operation. Fixed machine like carding machine also needs extract ventilation.

Minimum capture velocities are given in Table 10.3, for the capture of dusts, fumes, gases, smokes, mists etc.

Table 10.3 : Recommended Capture Velocities:

Releasing Velocity	Minimum Capture Velocity in		Examples
	fpm	m/s	
Low, into quiet air	50 to 100	0.25 – 0.5	Evaporation or fumes from open vessels, degreasing, pickling, plating.
Slight, into moderately quiet air	100 to 200	0.5 – 1.0	Spraybooth, low speed conveyor, cabinet, welding, dry dumping.
High, into rapid air movement	200 to 500	1.0 – 2.5	Spray painting in small booth with high pressure, conveyor loading, barrel filling, crushers.
Higher, into very rapid air movement.	500 to 2000	2.5 – 10	Grinding, blasting, rock, surfacing, tumbling.

Note : Similar to Table 3, IS:3103

See part 10 for worked examples.

(3) Emergency Ventilation : It is a type of mechanical local exhaust ventilation where specialised air ducts for delivering air may not be necessary. It is useful in gas-generating plants and compressor-rooms where risk of sudden outburst of explosive or flammable gases or vapours exists. At least 8 air changes per hour is necessary. Axial fans are selected for spark-free operation. Automatic switches are required to operate the system at the time of emergency.

(4) Other Methods : Despite of above three types of ventilation system for contaminants control, other methods of prevention are: Substitution, segregation, enclosures, natural and general mechanical ventilation, wet methods, use of personal protective equipment and warning and publicity.

In **substitution** safe substitute should be found for a toxic material.

In **segregation** the hazardous process and persons are kept away by means of suitable partition or increasing their distance.

Enclosure prevents contaminant of surrounding by physical separation of toxic material or process by enclosing them.

Wet method uses water spray to prevent dust escape into atmosphere. In

Dust suppression method jet or spray is applied to cutting tool, chisel, grinder, saw etc. to wet the surface for dust suppression.

Dust prevention includes both, wet method and dust suppression method. Using paste instead of powder, dipping in water, oil or other suspension are useful for gases, dusts and clothing. Proper personal protective equipment should be utilised as the last control against contaminants.

7.4 Air Distribution :

In any type of ventilation, proper air distribution is most important. Air should be distributed evenly without dead air pockets or undue drafts of high inlet velocities. The size and distribution of windows, inlet and outlet openings, ducts, fans, air inlet grills should be properly located considering orientation, prevailing winds and building and process layout. Normally air movement below 60 m/min without objectionable draughts should be provided in the vicinity of workers for better comfort High air movement may be required for heavy manual work. A blast of air up to 300 m/ min may be directed at the workers working in high temperature and high humidity, for velocity cooling.

7.5 Air Conditioning :

By air conditioning (AC) normally people mean 'air cooling' but it is not necessarily so. In a very cold country, room air heating (to maintain comfortable temperature) is also air conditioning. Its prime purpose is to keep air in a condition comfortable to man.

Air conditioning means conditioning the air for maintaining specific conditions of temperature, humidity, air circulation and dust level inside an enclosed space or room. The conditions to be maintained are dictated by the need for which the space is intended for.

When air conditioning is designed for human beings, it is called comfort conditioning as it keeps into account the regulated flow of air, its temperature, humidity and cleanliness most favourable, bearable and comfortable to men. But when it is designed to preserve things at low temperature, it is called refrigeration.

Why comfort air conditioning is required ? Because of physiology of heat regulation in human body only. Due to metabolism the body temperature is maintained at 37°C (98.6°F). But the skin temperature varies according to the surrounding temperature and relative humidity. When the surrounding is at very low temperature than the body temperature (e.g. cold winter), the rate of heat flow from the body (through skin) is rapid and the person feels cold. When the outside temperature is higher than the body temperature (e.g. hot summer) heat flow from the skin is restricted and the person feels heat. In this situation the water from the body evaporates at the skin surface (perspiration). This brings down the skin temperature and gives cooling effect. But if the outside is hot as well as humid, rate of perspiration will decrease and the person will feel hot and uncomfortable. Air movement by a fan accelerates perspiration and relieves discomfort.

Therefore to provide comfort by air conditioning, it becomes necessary to maintain room temperature and relative humidity at certain level so that the heat dissipation from the skin remains steady. In addition to tins, the air movement (draft) should be gentle and uniform to create a feeling of comfort. For this purpose the air delivered from the air conditioner picks up the heat and moisture from the room with a uniform comfortable air flow. The air is sucked back for mixing with fresh air and reconditioning to enable it to again pick up heat and moisture from the room. To take away the heat generated by breathing, infiltration into room through door and wall openings, electric fixtures, machines and equipment, a sufficient quantity of conditioned air has to be circulated into the room. If the room size is large, more air-distribution ducts and supply outlets (called supply grills), and more return-air grills and ducts (passages) are required for uniform effect at all points inside the room.

In summer when cooling is required, air is cooled and dehumidified by the use of refrigeration system. For severe winter regions, the air conditioner unit provides heated air to the conditioned space.

Air filters are provided before the cooling coil to arrest dust carried by the return (fresh) air. The air filters also protect the cooling coil against dust accumulation.

For small room, normally 0.75 to 2.5 tonnes capacity and for larger area 5 to 15 tonnes capacity air conditioners are required. The compressor, motor, evaporator, condenser, throttling device and air circulating fans are the main parts of any air conditioning unit.

Air conditioning processes are as under :

1. Cooling only (without humidification or dehumidification).
2. Cooling and dehumidification.
3. Cooling and/or Heating,
4. Finned cooling coils with direct expansion.
5. Cooling with humidification, and
6. Desert coolers.

The desert cooler or air cooler works on the principle of evaporative cooling. A fan sucks outside air through a wetted pad which is kept continuously wetted by circulating water through it (independent circuit). The air passes trough the wetted pad, gets cooled and humidified and discharged into the room where it picks up sensible heat and maintains fairly comfortable condition. The heated air escapes from the room openings i.e. the same air is not taken back in ducting. As a fresh air it may come back through the wetted pad.

Thus the purpose of air conditioning is to provide the most comfortable ventilation and better heat control at home and also at some specified industries (e.g. electronic, computer/telephone, watch, pharmaceutical industry).

The hazards associated with industrial air conditioning plants (e.g. chilling plants, cold storage, central AC for theatre, auditorium, dairy etc.) are:

1. Leakage of refrigerant. Ammonia leak has toxic effect and compounds of chloro-fluoro-methane has ozone depletion effect (environmental hazard). Ammonia leak is detected by smell or SO, torch (gives white smoke) and leakage of other gases by Halide torch or electronic gas detector.

   Common refrigerants are R-717 or Ammonia (NH_3), R-11 (CCl_3F), R-12 ($CC1_2F_2$), R-22 ($CHCIF_2$) and R-502 ($CHCIF_2$, + $CC1F_2CF_3$)

2. Pressure of compressed gas in cylinder, condenser and pipelines. Appropriate safety valve or pressure controller, pressure gauge, isolation valve, drain, etc. are required. Periodical pressure testing (normal and hydraulic) is also necessary.

   For safety code see IS 659 & 660.

7.6 Ventilation for Special Operations:

Open Surface tanks for anodising, pickling, acid dipping, plating, etching etc., involve heat and gassing. Depending upon the rate of evolution, type of ventilation needed may be : enclosing hood, lateral exhaust, overhead canopy hood, general room ventilation etc.

Spray Booths for spraying paint, enamel, bleaching, glazing, welding etc., require deeper spray booth or baffles of non-flammable materials.

Foundries need dust control in shake out and cleaning rooms where 'wet method may be suitable. In a mechanised foundry tight enclosing hood and side hood on the shake out gate are useful. Sand conveying and reconditioning equipment should be completely enclosed and ventilation should be provided at dust producing spots.

Grinding, buffing and polishing operations need local exhaust systems. Hoods on grinding and cutting wheel for local exhaust with an adjustable tongue to peel off the dust carried around the wheel in the air stream set up by the wheel's rotation, are desirable. Not more than 25% of the wheel should be exposed. Velocity in branch ducts and main duct may be @ 4500 and 3500 fpm respectively. Swing grinder should be housed in a booth. Portable hand grinding can be done in a booth or on a table with downdraft ventilation.

Woodworking machinery need exhaust ventilation. Cyclone arrester is used to collect scrap.

Cast-iron machining needs hood design according to the machine tool. Small local hoods with face velocities 400 to 2000 fpm may be suitable.

Similarly local hoods of special design are needed for oil melting furnaces, petrol engines etc.

8 CONTROL OF HEAT EXPOSURES

Control of heat stress is explained in foregoing part 5.5. '

control criteria, see part 6.3, and for some design factors part 6.4.

In addition to the ventilation, natural or mechanical, as explained above, it becomes necessary in process situations to apply other means for control of heat exposures toward workers. They are as follows:

8.1 Control at Source (Isolation or Segregation) :

The first obvious step is to isolate the heat sources wherever possible or to segregate them. Some of the hot process equipment could be placed out of doors with only a protective roof.

The location of furnaces in separate wings rather than in a large single building will simplify the problem of supplying air f6r general ventilation. These wings may have high roof to provide better chimney effect for the removal of hot air over the furnaces. Hot process or area should be enclosed where conditioned air can be supplied.

Provide engineering Controls for general air movement, shielding of radiant heat sources and to reduce process heat, water vapour release and metabolic rate.

Set acceptable exposure times and allow recovery form body strain.

8.2 Insulation:

The insulation of furnaces and other heat producing equipment will not only reduce the amount of heat exposure but also result in the consequent saving in fuel consumption. If all the heat produced by a process is released into a. workroom and the heat production is constant, no amount of insulation around the process can reduce the heat exposure. The insulation will be of value only when heat produced has several avenues of escape, the dissipation into the workroom being only one of these. In such cases, a combination of insulation and exhaust or gravity ventilation will be quite effective.

To reduce solar heat radiation false ceiling, (double roofing) or painting the roof by heat reflecting surface or colour (e.g. white) is useful. Pipes, vessels and other hot surfaces should be insulated to reduce heat radiation from them.

8.3 Substitution:

If possible the hot process should be substituted by localised or more efficiently controlled method of heating. For example, cold riveting or spot welding instead of hot riveting and induction hardening instead of heat treatment.

8.4 Local Exhaust Ventilation :

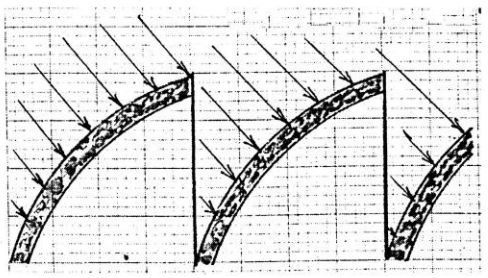
Another method of removing the heat from the source is by providing ventilated enclosures such as canopy or exhaust hoods by which natural convection column of heated air rises from a hot process environment This will minimise the temperature rise in the space around the hot process.

See foregoing part 7.3.2(2) for details.

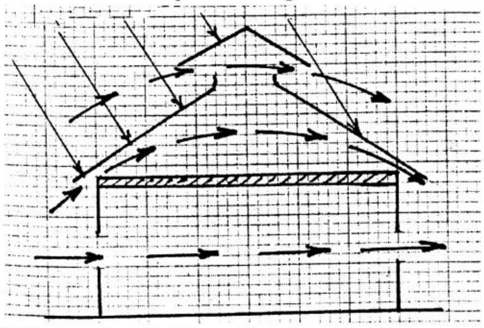
8.5 Control of Radiant Heat :

In some industries the frequency of very hot 'objects and surfaces such as furnaces, ovens, furnace stacks, molten material, hot ingots of metal, castings, and forging is such that the major environmental heat load is in the form of radiant heat which may be several times greater than the convective heat load. No amount of ventilation with or without air cooling will reduce the heat exposure since air temperature has no significant influence on the flow of radiant heat.

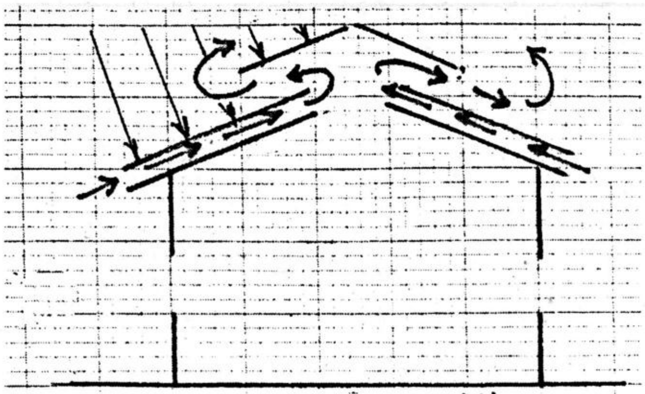
The only effective control is decreasing the amount of radiant heat impinging on the exposed workers. This can be accomplished by either lowering the surface temperature 'of the hot equipment (by insulation or by water cooling), or by radiation shielding. A shield is simply a sheet of material, opaque to the infra-red waves placed between a hot object and work surroundings. The shield should not contact the radiating surface and the presence of a ventilated air space between the hot object and the shield to avoid heating of the shield by conduction and to remove the heated air in between. Materials best suited for radiant heat shields are those with surfaces that maintain the high reflectivity for radiant heat and low emissive under plant conditions. Aluminium sheet has these properties. It is the most common material used for radiation shielding.



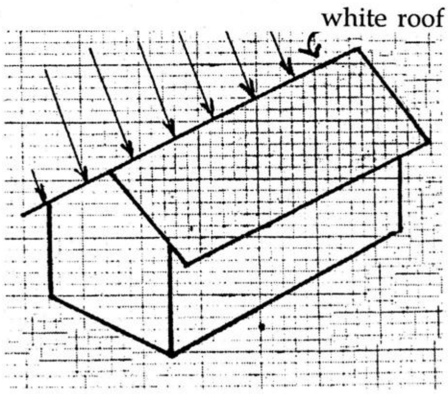
Insulated roof for protectiion against solar radiation



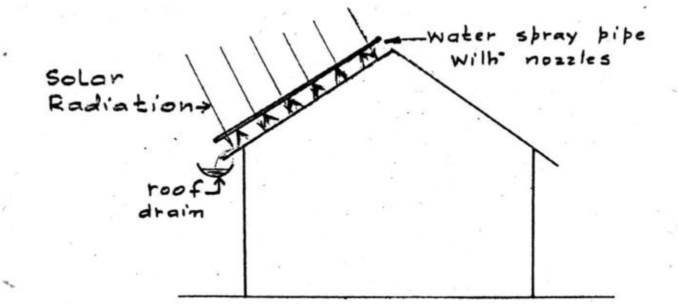
Pitched roof with false ceiling for protection against solar radiation



Double roof with ventilated air gap. Interior unaffected by solar radiation



Roof painted white reduces effect of solar radiation



Roof spraying process produces evaporation and cooling

Fig. 10.13 Control of Radiant heat.

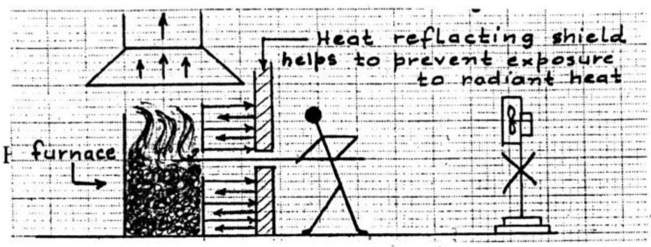


Fig. 10.14 No faning can reduce the effect of radiant heat from "Hot process"

Roofs of corrugated iron sheets or asbestos cement sheets get heated by sun in hot weather and act as a constant source of heat, the major portion of which is radiant heat. Control of this type of heat' exposure may be achieved by lowering the surface temperature of the roof by :

1. Insulating roof by providing a layer of material of low conductivity.
2. Shielding by the provision of a false roof or ceiling with sufficient air space ventilated to outside atmosphere.
3. White-washing or white painting the exterior surface of the roof.
4. Spraying of water intermittently over the roof to cool it by evaporation.
5. Openings and glazing in the walls and roof through which sun rays penetrate in summer should as far as practicable be screened.

8.6 Local Relief :

In certain situations when a general reduction of heat exposure throughout die plant is not otherwise feasible, relief may be provided locally, i.e. at the work place by surrounding the exposed worker with an acceptable thermal environment by providing positive ventilation. The following three methods may be employed depending on the work situations :

1. Providing a complete enclosure around the worker with a separate ventilation in order to'. maintain cooler working conditions. This may be in the form of air-conditioned control room, small shelter booth, or ventilated crane cab.
2. Surrounding the worker with a relatively cool atmosphere by a direct supply of air introduced at the working level or over a small area of the plant.
3. Directing a high velocity air stream at the worker when the air is capable of absorbing heat i.e. either its dry bulb temperature is reasonably lower than the body temperature or its humidity is low enough to allow evaporation of sweat.
4. Give a cup of cool palatable drinking water at 20 to 30 minutes.
5. Give training about heat stress and strain and their control measures.
6. Encourage consumption of salty foods if medically not restricted.
7. Permit self limitation of heat exposures and frequent rest intervals.

8.7 Personal Protective Equipment

In certain operations, such as glass drawing, blowing or enamelling, metal melting furnace etc., the workers may be required to work within reach of hot objects which may be at temperature of 800 °C (1472 'F) or higher and the time required for operation may reach 10 to 20 minutes. In such situations, protective clothing and protective shields of heat reflecting type can be used for controlling heat exposures.

The protective clothing is generally made of aluminised asbestos cloth usually backed up with felt or other insulating material. Aluminised fibre glass, aluminised cotton duck or aluminium sprayed, asbestos have also proved effective. The operator may be equipped with mitts, leggings, apron, jacket, helmet, and special arm sleeves according to specific operations. The protective clothing must not be very heavy and should be flexible enough to permit free movement. Only those parts of the body which are facing the hot objects need be covered. .

Pay attention on signs and symptoms of heat induced disorders and provide remedy.

9 TESTING AND MAINTENANCE OF VENTILATION SYSTEMS

This is most essential for the upkeep of all ventilation equipment. Fans and other equipment shall be so located that maximum fresh air intake or exhaust air outlet, accessibility for repair and maintenance and noise reduction are possible. In flammable areas fans of non-sparking construction and motors of flameproof construction are most desirable. They will be so placed ' that any explosion will not vent into the workroom. The ducts should be properly laid and connected air tight. Their easy inspection, replacement, repair and maintenance should be possible. The metal duct work should confirm to IS:655. Dampers will be provided where necessary.

The testing of ventilation system should Check

1. Volume flow rates (Q) at the supply and exhaust openings to meet the design specification.
2. The system is not causing excessive noise and vibration.
3. Designed air quality is maintained at all times.
4. Control measures if the toxicity of inside air is increased.
5. Outlets from factory premises do not cause air pollution for community.

See Part 4.3 for measurement of air velocity, volume flow rate, toxicity of air etc.

Intake (plenum) shafts to work as air inlet, ducts for carrying fresh or exhaust air, Humidifiers to maintain desired humidity. Air heater to heat air in cold period. Air ejector for exhaust of flammable or explosive gases and dusts from workrooms. Fans of various types (centrifugal, axial, propeller) to deliver or exhaust large volumes of air, and Motors are such ventilation equipment which need good installation, operation and maintenance.

Air cleaning equipment or collector such as Dust collector or De-dusting chamber to precipitate suspended dust, cyclone - a dust extractor wherein dust is separated from the cyclonically rotating dusted air by centrifugal force. Bag filter (house) to separate air depositing the fine dust particles on outside of the canvas. Oil filters for fine cleaning of the air in which dust concentration are up to 10-20 Inrr/m3 Paper filters to clean the plenum air from the fine dust and' Electrical precipitators to attract and collect airborne dust particles in electric field are also equally important for maintenance purpose.

Industrial ventilation is, thus, a complex installation which requires skilled and specially trained personnel for proper operation and maintenance. A maintenance book or register should be kept with each ventilation unit Instructions for startup, shutdown, maintenance, repair, operating parameters, nature of trouble and its elimination and trial runs should be recorded in the register. While testing a ventilation system, the fans should be checked for its efficiency, pressure and speed. Unguarded moving parts should not be touched.

Indian Standards useful for electrical safety are 732 and for fire safety 1646.

Personal protective equipment such as special clothing, goggles, safety shoes, gloves, hard hats, aprons, ear protection, respiratory or lung protection including various dust filters and gas masks, barrier creams and detergents should be checked before use, well maintained and kept effective.

All ventilating equipment should be checked periodically, bearings and various moving parts should be lubricated and all metal parts and air cleaning devices including filters should be checked regularly for dust deposition, choking, corrosion and protected by anti-corrosion paint.

Filters and heat transfer units should be regularly cleaned for their efficient use. Dust or condensed vapour in the system should be cleaned. The integrity back pressure and efficiency of the filters and cyclones should be checked.

The equipment shall be tested as mentioned below for rated air delivery.

As discussed earlier, ventilation is created by positive draft or exhaust of air. The fans normally used arc centrifugal (air leaves the impeller at right angles to its axis), axial flow or propeller type (air leaves the impeller parallel to its axis). As per requirement of the air movement (including make up air) the fan and motor capacities are selected. Testing is required to check this rated (expected) air volume Q in m^3 / min.. This flow may fall down because of wear and tear, lack of lubrication, corrosion, choking of air filters, ducting etc. Testing of air flow can reveal this fact and suggest the necessary replacement or maintenance.

The volume of inlet air (outside air by positive ventilation) is given by $Q = kAV$
where A = Area of intake opening of duct in n12 and V = Average velocity of air in m/min, measured by a calibrated 'anemometer', velocity meter and pivot tube. Co-efficient 'k' varies from 0.5 to 0.6 when air openings face wind and 0.25 to 0.35 when openings are at angle.

The volume of exhaust air can also be measured by the same formula and manner.

Ventilation due to convection effects arising from temperature difference between inside and outside is
given by $Q = 7A \sqrt{h}(t_i - t_0)$

where Q and A as stated earlier, h = vertical distance between inlets and outlets in mm, t = temperature of indoor air at the outlet in °C and t = temperature of outdoor air in ^oC.

Variation of air flow through filters (or grills) should not be more than ± 20% of the mean value.

Turbulent air flow at the working zone can be measured by Kata thermometer, heated thermo anemometer or properly calibrated thermocouple anemometer.

10 WORKED EXAMPLES

Static Pressure (SP) is created by gravity and modified by the fan. SP is felt in all directions within die duct and is measured in such a way that the flow of air does not effect the measurement.

If the end of the manometer probe is inserted facing directly into the air stream, the manometer.

Equation: TP = SP+VP
Volume flow rate Q = Vx A
Where, Q = volume flow rate, cuft/min. V = velocity, feet
per minute, A = area, sq.ft.

Example-1

The cross-sectional area of a duct is A = 2.445 sq.ft. The average velocity of air flowing in the duct is V = 3500 ft/min. at standard conditions (STP). Calculate the flow rate, Q.

Q = V x A
= 3500 ft/min x 2.445 sq.ft
= 8557.5 cuft/min

Example-2

The diameter D of a round duct -is 25 cm. The average velocity of air flowing in the duct is V = 21 mt/ sec at standard conditions (STP). Calculate the flow rate, Q.

$A = \pi D^2/4 = \pi\ (25cm)^2 - 4$
$= (0.25\ \text{meters})^2\ /4 = 0.0491$ sq.mts.
Q = V x A
= 21 mt / sec x 0.0491 sq.mts.
= 1.03 cu.mt. / sec

Velocity and Velocity Pressure (VP)

$V = 4005\ (VP/d)^{0.5}$ US units
$V = 4.043\ (VP/d)^{0.5}$ SI units

Where, V is velocity, VP is Velocity Pressure and D is Density correction factor

Example-3

The average Velocity Pressure of an air stream in a duct is VP = 1.00 inch w.g. Calculate the average velocity. (Assume STP, d = 1.0)

$V = 4005\ (VP/d)^{0.5}$
$V = 4005\ (1.00/1.00)^{0.5}$
V = 4005 ft/min

Settling Velocity (Vs)

$Vs = 0.0052\ (S.G.)\ D^2$ US Unit
$Vs = (26.4 \times 10^{-6})(S.G.)\ D^2$ SI Unit
Where SG = D = Diameter of particle

Example-4

What is the settling velocity of iron oxide fume of 1.0 micron diameter? S.G.=.6.6.

$Vs = 0.0052\ (S.G.)\ D^2$
$= 0.0052\ (6.6) \times 1.0^2$
= O.OSft/min

$Vs = (26.4 \times 10^{-6})(S.G.)\ D^2$
$Vs = (26.4xl0^{-6})\ (6.6)1.0^2$
= 0.00017 mt/sec

Hood Entry Loss

The hood entry loss, H is the sum total of all the losses from the hood face to the point of measurement in the duct.

He = K .VP.d

Where: H_e = Hood entry loss (US units: inch w.g., SI units: mm w.g.)

Example-5

Calculate the hood entry loss, if the duct velocity pressure VP = 18.5 mm w.g. and the hood static pressure

SP_h = 26.5 mm w.g.
$H_e = SP_h - VP$ = 26.5 mm - 18.5 mm = 8.0 mm w.g.

Fan

The Fan Total Pressure is often designated as FTP or TPF. FTP represents all energy requirements for moving air through-the ventilation system. FTP is calculated by adding the absolute values of the average total pressures found at the fan.

FTP = TP outlet - TP inlet
TP outlet = SP out+VP out
TP inlet =SPin+VPin
FTP =SPout+VPout-SPin-VPin
=SPout-SPin (if VP out is = VPin)

To size a motor one should find out air power (ap), brake power (bp), shaft power (sp) and rated power (rp).

Air horse power refers to the minimum amount of power to move a volume of air against the fan total pressure.

Ap = FTP. Q.d / f

Where

ap is air power (US unit: bhp and SI units =kW).

FTP is Fan Total Pressure (US units = inches w.g.

SI units = mm w.g.) w.g. = Water gauge
d is the density correction factor
f is a unitless factor (US units = 6356 and SI units 102.2)
bp = ap/eff -FTP. Q.d /f.eff.

Example-6

What is the required power to install local exaust ventilation and what rated power motor should be selected from following data ?

	US unit	SI unit
FTP	5.0 inch w.g.	127 mm w.g.
Volume rate	Q 12000 s.cuft/m	5.664 s.curnt/sec
Eff	0.60	0.60
Kdl	1.10	1.10
STP d	1	1
f	6356	102.2

Note : In volume rate s denotes standard condition

$$\text{SP(Shaft Power)} = \frac{\text{FTP x Q x Kdl x d}}{\text{f x eff}}$$

$$= \frac{5.0 \text{ x } 12000 \text{ x } 1.10 \text{ x } 1}{6356 \text{ x } 0.6}$$

$$= \quad 17.3 \text{ HP} \qquad \text{(US Unit)}$$

$$\text{SP (Shaft Power)} = \frac{FTP \times Q \times Kdl \times d}{f \times eff}$$

$$= \frac{127 \times 5.664 \times 1.10 \times 1}{102.2 \times 0.6}$$

$$= \quad 12.9 \text{ KW} \qquad \text{(SI Unit)}$$

Example-7 (Heat Stress Calculation)

An acclimatized worker with summer work uniform (ACGIH clothing correction factor-O) is exposed to heat at various locations of foundry during different processes as shown in following table. An Industrial Hygienist found following results of measured parameters by WBGT (heat stress monitor) meter. The worker was engaged in heavy work with 50% of work and 50% of rest. Calculate his average heat stress exposure and state whether it is within permissible limit or not.

Processes	Result in WBGT °C	Duration of Exposure in Minutes
Charging of metal in Cupola furnace	40°C	20
Observing and working near Furnace	48°C	120
Unloading of molten metal in ladle	65°C	20
Fettling Operation	45°C	50

$$\text{Average WBQT} = \frac{(WBGT_1)\ (t_1) + (WBGT_2)\ (t_2) + \ldots.. + (WBGT_n)\ (t_n)}{t_1 + t_2 + \ldots. + t_2}$$

Average WBGT = (40 x 20) +(48 x 120) +(65 x 20) +(45 x 50)/210

Average WBGT = (800) + (5760) + (1300) + (2250) / 210 Average WBGT = 48.14° C

Considering the correction factor of clothing WBGT = 48.14 + 0 = 48.14° C

Considering factors of acclimatizing, percentage of work & rest and heavy work the exposure limit recommended by ACGIH (2006) is 28.5° C

In present case, worker is exposed to (48.14° C) more than the recommend value of heat exposure (28.5° C).

Therefore, control measures are necessary to bring down the exposure level from 48.14° C to 28.5° C or less.

E X E R C I S E

1. Explain, State, Mention or Discuss:

1. The purpose or objective of ventilation and heat control.
2. Statutory provisions regarding ventilation.
3. Parameters of thermal environment and methods of their measurement.
4. Different factors affecting heat stress and measures to control them.

5. Heat balance equation and factors affecting it
6. Effects of hot and humid environment on safety and efficiency.
7. The concept of WBGT and its usefulness.
8. Effects of cold stress, factors increasing it and factors decreasing it.
9. Health disorders in hot environment.
10. Safety problems due to increased temperature.
11. Engineering controls to reduce effects of parameters of Heat balance equation.
12. Methods of personal management (administrative efforts) to control heat stress.
13. Following terms:
    (1) Dry & wet bulb temperature (2) Capture Velocity (3) Due point (4) Dilution ventilation (5) Exhaust of air (6) Effective temperature (7) Local exhaust ventilation (8) Plenum ventilation (9) Evaporative cooling (10) Roof ventilation (II) Emergency ventilation (12) Air conditioning ~ (13) Spray booths (14) Local relief (15) Insulation OR Substitution (16) Comfort zone (17) Dust collectors (18) Hood (19) Air cleaner (20) Dust.
14. Factors that help acclimatization.
15. Design factors of a ventilation system.
16. Mechanical ventilation for Building .and process (contaminants) control.
17. Different types of ventilation for a factory building.
18. Points of consideration while designing a hood for local exhaust ventilation.
19. Ventilation for special operations.
20. Maintenance aspects of ventilation systems.
21. Various types, of roof for a factory building and methods to improve natural ventilation. Explain by sketch.
22. Indices for heat and cold stresses.

2. Write short notes on :

1. Effects of good ventilation.
2. Effects of bad (poor) ventilation.
3. Important Indian standard on code of practice for Industrial ventilation.
4. Types of instruments to measure air movement.
5. Pilot static tube.
6. Effects of heat on skin.
7. Reasons of discomfort.
8. Factors decreasing ability to with stand high temperatures.
9. Heat disorders on human body.
10. Oxford Index OR Wind chill Index.
11. Predicted Four Hourly sweat rate.
12. Protective measures against cold stress.
13. Causes of temperature rise in industry.
14. Acclimatisation.
15. Requirement of fresh air.
16. Principles and selection criteria for air cleaning devices.
17. Classification of ventilation systems.
18. Natural ventilation 05 Roofed ventilation.
19. Cowl type roof ventilation.
20. Local exhaust ventilation and its design aspects.
21. Air conditioning and hazards associated with it.
22. Control of heat exposures at source.
23. Control 'of Radiant heat.
24. PPE while working in hot processes.
25. Points of testing of a ventilation system.

26. Physiological effects of 'heat on factory workers.

3. **Explain the difference between :**
   1. Good and bad ventilation.
   2. Dry bulb thermometer and Glob thermometer.
   3. Hygrometer and hygrograph.
   4. Vane anemometer and cup anemometer.
   5. Kata thermometer and Glob thermometer.
   6. Pressure tube manometer.
   7. Smoke tube and Gas defection tube.
   8. Heat stress and cold stress.
   9. Heat stress and heat strain.
   10. Effective temperature (ET) and corrected effective temperature (CET).
   11. Wind chill Index and wind chill cooling rate.
   12. Different methods for control of heat stress.
   13. Positive & Negative ventilation.
   14. Absolute & Relative humanity.
   15. General ventilation and Natural ventilation.
   16. Make up air and Air changes.
   17. Comfort ventilation and Air conditioning.
   18. Insulation & substitution to control heat exposures.
   19. Segregation & Enclosure.
   20. Dust suppression & dust prevention.
   21. Air distribution and Air conditioning.
   22. Cyclone separator & Fabric filter.
   23. Exhaust ventilation & Plenum ventilation.

4. **Comment on the following explaining whether it is true or not**
   1. Human body (core) temperature varies and equals the environmental temperature.
   2. Heat stress is affected by climatic factors but not affected by non-climatic factors.
   3. Acclimatisation helps to tolerate heat stress.
   4. Cotton clothing are most comfortable for decreasing heat stress.
   5. Good ventilation increases comfort and bad ventilation decreases it.
   6. Temperature alone is not a good indicator of comfortable conditions.
   7. Toxic effect of chemical increases as temperature increases.
   8. Natural ventilation is preferable than mechanical ventilation.

Reference and Recommended Reading

1. Code of Practice for Industrial Ventilation, IS:3103.
2. Training Material, TM-4 & 5, ILO, Bangkok.
3. Encyclopaedia of Occupational Health and Safely, ILO, Geneva.
4. Occupational Health and Safety in Manufacturing Industries, M K Poltev, Mir Publishers, Moscow.
5. Psychology for Business and Industry, Herbert Moore, McGraw-HiU.
6. Pollution Control in Process Industries, 'Tata McGraw-HiU, Delhi-110002.
7. Industrial Ventilation - Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, AGGIH, 1014 Broadway, Cincinnati, Ohio 45202.
8. Plant and Process Ventilation, Hemeon W.C.L., Industrial Press, 200, Madison Ave., New York.
9. Design of Industrial Exhaust System, Alden John L., Industrial Press, New York.
10. Heating, Ventilating and Air Conditioning Fundamentals, William H Sevems and Julian R Fellows, Chapman and Hall, London.

11. Steel Mill Ventilation, American Iron and Steel Institute, 150, East and 42nd St., New York 10017.
12. Engineering Manual for Control of In-plant Environment in Foundries, Amer, Foundryman's 29Society Inc., Illinois 60016.
13. Flow and Fan, C Harold Berry, Industrial Press, New York.
14. Cyclone Dust Collectors, Engineering Report by Dust Collector Project Committee of the Amer. Petroleum Institute, Washington D.C.
15. Basic Principles of Ventilation and Heating, Thomas Beford, H K Lewis & Co., London.
16. Human Stress, Work and Job Satisfaction, ILO, Geneva.
17. Course on Dust Prevention in Industry, ILO, Geneva.
18. The Factories Act and Rules.
19. Fundamentals of Industrial Hygiene, NSC, USA.
20. Basic Refrigeration and Air Conditioning, PN Ananthanarayanan, Tata McGraw-Hill, Delhi 110002.
21. Accedint Prevention Manual for Business and Industry by NSC, USA
22. Automation, Work 'organization And Occupational Stress by ILO
23. Preventing Stress At Work by ILO
24. Handbook of Ventilation for Contaminant Control, By Henry J. McDermott
25. HVAC Systems Design Handbook by Roger Haines and Lewis Wilson
26. Industrial Ventilation : A Manual of Recommended Practice for Design by ACGIH
27. Industrial Ventilation: a Manual of Recommended Practice for Operation and Maintenance by ACGIH
28. Industrial Ventilation Workbook by D. Jeff Burton
29. Laboratory Ventilation Guidebook by D. Jeff Burton
30. Useful Equations-Practical Applications of OH & S Math by Jeff Burton
31. Ventilation for Control of the Work Environment, by William A. Burgess, Michael J. Ellenbecker and Robert D. Treitman

CHAPTER – 11

Electrical Safety

THEME

1 ELECTRICITY, ITS USEFULNESS AND HAZARDS

1.1 Usefulness of Electricity :

Electricity and electronics are not much old sciences. Till 1890 physicists were asking What is Electricity? With the beginning of 20th century, electricity entered and today it has changed the whole industrial, economic and social picture. Faster and mass production and advancement of life could .not have been possible without electric power which has become the major source of prime movers for most of the machines. Electricity has illuminated many areas of life viz. industrialisation, light, sound, heating, cooling, education, computer, transportation and numerous essential human services. Its domestic uses are day by day increasing. A variety of kitchen appliances and other electrical equipment have touched almost every corner of our modern life. But it is to be handled with care, because its contact with human body is dangerous and proves fatal if not properly controlled by engineering and manual precautions.

Demand of electricity is ever increasing because of its growing need for industrial mass production, urban and rural electrification, domestic and agricultural use, pump-sets demand for water etc. In 1995-96 total 380 and in 1996-97 total 394.5 thousand million units (kwh) electricity was produced. During 1997-2002, in the 9th Plan, an increase of 57734.7 MW was recommended. 25 private power projects of 141000 MW capacity were sanctioned.

1.2 Accidents & Hazards :

Accident tables T 5.7, 5.8, 5.20 and 5.22 given in Chapter-5 reveal that in India and Gujarat, electrical fatal accidents are @ 2 to 7% of the total accidents. Mode of fatal accidents due to electricity is increasing. With the constant increase of per capita consumption of electricity, the chances of electrical accidents may also increase. It is also important to note that the accidents on low voltage (230 V) working are more than that on high voltage working, and untrained people are more involved than the trained people.

At **Uphar cinema hall** in Delhi, 59 died in fire due to electricity in 1997. Therefore 107 cinema halls, restaurants and banquet halls were given notices on 2-7-97 by the Delhi Vidyut Board for various deviations from the 17 electrical safety conditions. As per Delhi Fire Service's report, 70% of more than 2000 fires during that period had occurred due to short circuits (News 101-98).

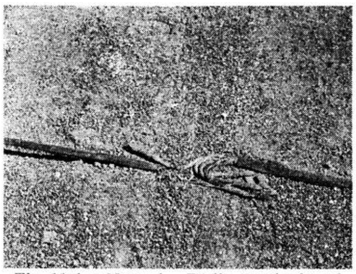


Fig 11.1 : Hazard - Badly crushed and tapped electric wires lying on the road

Loose Electric wires or cables lying on the road are crushed by moving vehicles. Allowing them in tapped condition create hazard. Such condition should be avoided See Fig. 11.1

One old Pennsylvania study gives the following break-up for electrical accidents.

	Cause	%
1.	Overloading, Poor arranging.	36
2.	Unsafe or improper use of equipment.	31
3.	Working on moving or dangerous equipment.	16
4.	Unnecessray exposure to danger.	10
5.	Not using the personal protective equipment.	5
6.	Improper starting or stopping.	2

A study of the electrical equipment industry in Germany shows accident to body sites as shown in figure 11.2:

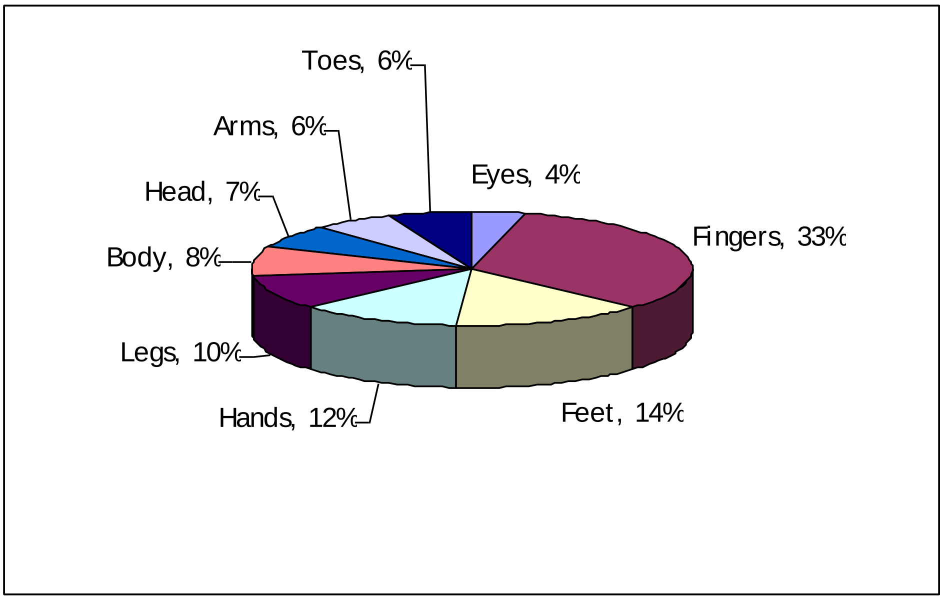


Fig 11.2 : Body site injuries

This percentage is variable, but it indicates the areas of hazards need to be controlled. Main electrical hazards are:

1. Electric Shock.
2. Electric Burns.
3. Fire and Explosion.
4. Hazards due to Electric Welding and Cutting
5. Hazards due to static electricity.
6. Fall of lightening from the sky.

Shock and burns are injury from direct contact. They cause accidents of three types (1) Hold-on type (2) Ventricular fibrillation and (3) Respiratory arrest.

Injuries are possible without current flowing through body, e.g. burns due to electric arcs, radiation, electromagnetic field, falling or injury due to sudden starting of machine, equipment etc.

Main protections are proper fuses, switchgears, circuit breakers, earthings and bonding. Such electrical safety precautions are highly needed to prevent accidents .due to electrical hazards.

2 STATUTORY PROVISIONS

2.1 Factories Act and Rules:

However the Factories Act and Rules do not contain any details of electrical safety and therefore no effective implementation of the electrical safety is possible through this Act. No prosecution is possible for such purely electrical causes except u/s 7A.. Only section 36 A speaks of portable electric light of less than 24 V and section 37 requires effective enclosure to sources of ignition. Which includes flame proof electric fittings.

Rule 86 of the Karnataka Factories Rules, 1969 provides as under:

"Electricity - (1) No electric installation shall be provided in factory, so as to be dangerous to human life or safety in the opinion of the Inspector. Provided that the Inspector may issue an order in writing, specifying the arrangements necessary for adequate safety, in addition to what is provided under the provisions of Indian Electricity Act or Rules there under. (2) In the main switch board or switch boards of factories, there shall be provided earth leakage and overload relays. The earth leakage relay shall be so provided that the leakage current shall not cause electrocution or other hazard."

These provisions are insufficient to scrub violations of electrical safety rules. This may be due to the separate Electricity Act and Rules as follows: 2.2 Electricity Act and Rules:

Electricity Act 2003 and Rules' 1956 &2005 require many safety aspects. Under these rules the consumer is responsible to maintain his electrical installation fully safe and certified. An inspection by Electrical Inspector is also required. For details see Part 2 of Chapter-28.

3 INDIAN STANDARDS

3.1 List of Standards.

Many IS are available on electrical safety such as : Current passing through human body, effects 8437, Drilling machines, flameproof, for use in mines 9192, fuses 2086, 1884, 3106, transformers. Safety 1416, lifts dimensions 3534, lighting fittings - flameproof 2206 (Part I to 4), safety requirements for luminaries 1913/ waterproof 3528, water tight 3553, power connector; 5561, shock-equipment for protection against 9409, strength test for solid insulating material 2584, electrical accessories 5133, apparatus and circuit intrinsically safe 5780, control devices operating electrical apparatus 7118, flameproof enclosures -2148, for use in explosive gas atmosphere 7693, spark test apparatus for 9166, testing 649, appliances-household, safety requirement 302, connections for lighting fittings, screwless 6585, for explosive atmosphere 8239, 8240 8241, 4691, 7389, of machine tool 1356, installation - classification of hazardous areas 5571, 5572, sand filled protection of electrical equipment 7724, safe magnet telephones for use in hazardous atmosphere 6539, safety for rectifier equipment 6619, insulating materials 8765, 4249, 6792, environmental tests 8999, 9000, layout in residential buildings 4648, measuring instruments for explosive gas atmosphere 8945, relays 3842, 5834, 3231, resistance-material test 3635, power stations - fire safety 3034, wiring 732, 1653, 3837, 2669, dust-proof electric lighting fittings 4012, dust-tight electric lighting fittings 4013, dust-tight ignition proof enclosures 11005, flash back (flame) arrester 11006, lightning arrester 4850 (withdrawn), building protection against lighting 2309, static electricity, guide for control 7689, electro heat installation, safety requirement 9080, guide for safety procedures and practices in electrical work 5216, danger notice plates 2551, earthing, code of practice 3043, indicating instruments 1248, 3107, 9319, induction motors 900, starters 5124, switches push button 4794, heavy duty 4047, electrical equipment for use in medical practice 8607 (Part I to 8), warning symbols for dangerous voltages 8923, safety requirement for measuring instruments 9249, safety requirements for refrigerators, food freezers 10542, building for installation of electric apparatus for gas atmosphere, rubber mats 5424, rubber gloves 4770, safety for audio amplifiers 1301, electric wiring in hospitals 7733, wiring voltage exceeding 650 volts 2274, not exceeding 650 volts 732, overhead power and telecommunication lines concrete poles 7321 and portable methanometer (electrical type) 9937.

IS:5216 - Guide for Safety Procedures and Practices in Electric Work - Part I : General and Part 2 : Life Saving Techniques must be followed strictly. A form of permit-to-work and special instructions while working with such permit are given in Part 1. Use of IS for hazardous area classification, equipment to be used in such area and earthing practice are also recommended.

SP 30 National Electric Code compiling many IS on electrotechnology, and SP 31 on treatment for electric shock are most useful for safety purpose. Other special publication SP 39 on low-voltage systems, SP 48 on electric irons, SP 49 on electric water heaters, SP 50 on electric radiators and SP 51 on electric stoves are also useful.

3.2 National Electric Code (NEC) :

This Code was adopted by the Indian Standards Institution on 15-6-84 and was first published in - August 1985. Its number is SP:30-1984.

The object as stated in the Code, is to complement the Indian Electricity Rules 1956 by way of elaborating as well as recommending practices to comply with their requirements. This Code is to provide information in a consolidated form to electrical engineers and contractors in the country who are concerned with the design and operation of electrical installations. The subject matter is divided into the following seven parts :

1. General and Common Aspects.
2. Electrical Installation in Standby Generating Stations and Substations.
3. Electrical Installations in Non-industrial buildings.
4. Electrical Installations in Industrial Buildings.
5. Outdoor Installations.
6. Electrical Installations in Agriculture Premises, and
7. Electrical Installations in Hazardous areas.

The information of each type of installation is further classified as under:

A. Assessment of the general characteristics of the occupancy from the point of view of the electrical installation therein.
B. Heavy current installation in the occupancy.
C Light current installation in the occupancy.
D. Specific requirement for protection and safety.

The Code lists various Indian Standards incorporated in the subject. As a safety aspect it also suggests permit-to-work system, safety instructions, safety practices, use of safety posters and treatment for electric shock. It provides details for terminology, principles, practices, selection of equipment, erection, testing, earthing, wiring, short circuiting, fire alarm system, protection, classification, safety etc.

As fundamental principles, the Code insists for-

1. Conformity with Indian Electricity Rules, Materials conforming to IS and good workmanship.
2. Co-ordination and co-operation between personnel.
3. Safe distance from electric lines.
4. Lighting, ventilation, heat insulation, lifts and location and space for electrical equipment.
5. Protection of persons, livestock and property and proper functioning of electrical installation.
6. Safety against shock currents and excessive temperatures.
7. Protection against direct and indirect contact, thermal effect, overcurrent, fault current and overvoltage.
8. Cross section of conductors, type of wiring, protective equipment, emergency control, disconnecting devices etc. Protective equipment should operate at values of current, voltage and time suitably related to the type of circuit and danger.

National Electric Code and Life Safety Code from National Fire Protection Association (NFPA), USA is also available on the subject.

3.3 TAC Regulations for Electrical System:

Above regulations published by the Tariff Advisory Committee (General Insurance), Bombay has been framed to ensure maximum safety to the insured property from the risk of fire/explosion due to the use of electricity. To that extent, these rules are different from the Electricity Rules 1956 and other statutory provisions. It includes requisite information from some Indian Standards and gives in its Appendix E a list of some useful IS.

These regulations apply to the entire electrical system from the point of supply to its use and covers all power equipment, switchboard, power distribution and motor control gear, transformer substation, earth connections, wiring, lighting fittings and accessories, electrical equipment and apparatus and requirements of specific occupancies like godowns, strong rooms, lifts, petrol stations, hazardous locations, machine rooms, high rise buildings etc. and testing.

The rules are comprehensive and in case of doubt it is suggested to refer the TAC, Bombay.

4 EFFECTS OF ELECTRICAL PARAMETERS ON HUMAN BODY

4.1 Physiology of Electric Shocks:

First major hazard due to electricity is shock to a person. It is the current, not voltage that causes physiological damage. But the current (1), voltage (E) and resistance (R> are inter-related by Ohm's Law, E=IR, and therefore all these three factors are important to control each other. Power (W) is W=EI and electrical energy is the product of power and time i.e. EFT and is given by a Joule (I Joule=l ampere at I volt for I second), I Joule/Sec is I watt and the practical unit for energy is the kilowatt-hour and .1 KWH is equal to 1.34 HP, the Horse Power, an another unit of electrical energy.

The blood is good conductor of electricity, but the skin is highly resistive. Unless the skin is punctured, no more current will flow through the body. Body resistance of each person is variable, therefore effect on them is also variable. Upto 10 mA, current can be barred with pain, but at 30 mA chest muscles do not work, breathing stops and death may occur. 250 mA causes complete death. Thus a leakage of 0.25 ampere is dangerous for human life. Sometimes after-effects are more severe than the actual shock or burn.

Electric Shock is an effect of a current flowing through nerves, muscles, heart or organs of a body. Electric shock is sudden and accidental stimulation of the body's nervous system by electric current which flows due to voltage difference.

The current may be DC (Direct Current) or AC (Alternating Current). DC may maintain involuntary grip on the live conductor which prolongs the current flow. Therefore the victim needs to be separated by a non-metallic rod or device. More DC is required than AC to cause the same effect. AC produces fibrillation every cycle whereas DC produces only once.

Low current disturbs body rhythm, sometimes stops heart if time duration prolongs but high current causes electric burns and sometimes death.

Shock may happen due to:

1. Contact with bare live conductor.
2. Removal of insulation of a conductor and its contact.
3. Short circuit due to sudden failure and the short circuit current not going to earth but flowing through human body.

4. Static charge on equipment discharges through human body.
5. Lightening.

The severity of shock depends on current value and the time of its passing through the body. 10 mA current can flow 5 seconds through the body without danger, while 100 mA flowing even for I second could be fatal. It also depends on type of current (AC or DC)/ frequency, path of the current through body i.e. passing nearby the heart or other nerve centre.

Personal sensitivity to electric shock varies from person to person. It depends on age, sex, heart and wetting of skin which varies the resistance of body. But as the supply voltage and frequency are same throughout the country (e.g230 V, 50 c/s) and normal body resistance of a 50 kg or 60 kg man is also same for the equal' condition, the current values are determined (by experiments) to find their effects on body. These are stated in tables in Part 4.2

A woman's body is more susceptible to electric Tents and the same effects may be produced with @ 60% the current required in a man.

At 30000 to 100000 c/s frequency the danger is less. Direct current of 0.5 A and above, and a surge of oscillatory energy from 10"to 30 watt-seconds may prove dangerous. For 50 c/s AC current, dangerous limit of voltage are 24 V for children and 60 V for adults. In wet 6ituation it is decreased (Statutory limit is 24 V).

The magnitude of the current flowing through the body depends on the applied voltage (current is directly proportional to voltage for the same resistance), the resistance of the path through body (current is inversely proportional to resistance for the same voltage) and the resistance in turn depends upon the area of the skin in contact with electrically live object, the moisture content of the skin (moist skin has low resistance, allows high current and is more dangerous ' than dry skin) and again the voltage. The resistance of body falls as the voltage or current is increased. See Table 11.4.

Temperature & humidity increase perspiration, which makes the body wet. This decreases resistance, allows higher current and is more serious condition.

Oxygen and Carbon Dioxide in air also affect. When oxygen is less or Carbon Dioxide is high in the air, body resistance reduces and the condition is like wet skin i.e. dangerous. The electrical hazards for welders increase for this reason.

Type of flooring, insulated, uninsulated, dry or wet has direct effect. Insulated and dry floor is safer than the uninsulated (conductive) or wet floor.

Position of body parts in the electric circuit through body is also important. If both the hands or both the legs touch live conductor, the effect is higher. The most dangerous condition is that of passing the current through heart.

Effect on heart is serious. 20 to 50 mA current passing through heart stops the heart so long as the current flows. Impurity of blood increases as the heart is not working. If this condition lasts for 5 minutes or n\ore, irreversible damage is caused to the brain (as oxygen is not reached there with the fresh blood) which may prove fatal. If the current is interrupted before that and the artificial respiration is promptly given to the heart, the patient will mostly recover.

If the current is increased 80 to 500 mA, the heart beat will stop and every fibre of it will contract haphazardly causing fibrillation. This will stop the entire blood circulation. Even a very short period of O.I second can cause this condition, and if the current is stopped after O.I second, the heart will never recover and death results after a few minutes. But it is possible to defibrillate the heart by using a device known as defibrillator. By this device a counter shock is given to the heart which reverts the heart muscles to their normal shape. However such device is available in the hospitals and the time factor is important to reach there.

Electric burns are caused due to high current flowing through body. Higher currents cause electric burns (joule burn, internal or flash over or thermal burn, external) and damage the nervous system. Electric burns internally heat the body (not ,visible from outside) and are curable by medical treatment. Due to high voltage and heavy current, sparking takes place and cloths also burn. This causes thermal burns and if they are extensive, the victim may die within few days.

According to Joule's law the heat generated is proportional to PRT, where I, R and T are current, resistance and time respectively. Burning takes place due to heat generated.

When human body, acting as earthed conductor, comes nearer to a high voltage conductor, the air insulation between them breaks down and a spark is developed between the two. Then current passes through the body to the earth causing flash burn.

In addition to flashing distance, flash burns can also be caused by heavy short circuiting or opening of an isolator carrying heavy load current.

For degree and percentage of electric burns see Part - 9 of Chapter - 26.

4.2 Effects of Amperages :

Following IS are most relevant:

IS:8437 Guide on effects of current passing through the human body :
Part -1 General aspects
Part -2 Special aspects

Effects of electric current on human body are summarised in Tables 11.1 to 11.3.

Table 11.1 : Current Range and Effect on a 68 Kg man

Current (50 Hz or c/s)	Physiological Phenomenon	Feeling or Lethal incidence
1 mA	None	Imperceptible
1 mA	Perception threshold	
1-3 mA		Mild sensation
3-10 mA		Painful sensation
10 mA	Paralysis threshold of arm	Cannot release hand grip, if no grip, victim may be thrown clear (may progress to higher current and be fatal).
30 mA	Fibrillation threshold 0.5 percent	Stoppage of breathing (frequently fatal)
75 mA	Fibrillation threshold 99.5 percent (5 second exposure)	Heart action discoordinated (probably fatal)
250 mA	Fibrillation threshold 99.5 percent (5 second	Heart and blood circulation may stop (usually fatal)

	exposure)	
4 A	Heart paralysis threshold (no fill fibrillation)	Heart stops for duration of current passage. For short shocks, may re-start on interruption of current (usually not fatal from heart dysfunction).
5 A	Tissue burning	Not fatal unless vital organs are burned.

Table 11.2 : Effects of DC and AC (current) on human body.

Current in mA			Effect
DC	**AC 50 Hz**	**Ac 10000 Hz**	
0-5	0-1	0-9	No sensation
6-55	1-8	10-55	Mild stock
60-80	9-15	60-80	Painful shock and hand unable to let go of live parts in case of AC
80-100	16-20	80-100	Some loss of muscular control
110-350	20-45		Severe shock and loss of muscular control
400-800	50-100		Possible heart failure (ventricular fibrillation)
>800	>100		Usually fatal
>1600	>200		Severe burns, severe fibrillation and death.

Table 11.3 : Effect of Electric Current on Men and Women

Current in mA						Effect
DC		**50 Hz AC**		**10000 Hz AC**		
Men	**Women**	**Men**	**Women**	**Men**	**Women**	
1	0.6	0.4	0.3	7	5	Slight sensation on hand
5.2	3.5	1.1	0.7	12	8	Perception threshold
9	6	1.8	1.2	17	11	Shock not painful, muscular control not lost
69	41	9	6	55	37	Shock-painful, muscular
76	51	16	10.5	75	50	Shock-painful, let-go threshold
90	60	23	15	94	63	Shock painful and severe, muscular contractions, breathing difficult.
500	500	100	100	-	-	Shock, ventricular fibrillation from 3 seconds
-	-	165 t	165 t	-	-	Short shock lasting ‘t’ seconds
50	50	13.6	13.6	-	-	High Voltage Surges
Energy in watt-seconds or joules						

Note : The figures are indicative and not absolute.

If a person gets electric shock and heart beat is not found, immediate remedy is an artificial respiration (see part-8 of Chapter-26) or resuscitation (CPR) to the person till he revives or death is diagnosed by a doctor. Minimum time should be elapsed before starting such respiration for possibility of success. This is indicated as under:

Time in Min	Possibility of Success
0-1	Best

1-3	Good
3-5	Fair
5-20	Poor

Therefore it is always advisable to give first-aid training including that of artificial respiration, to the maximum workers. Sec.45 & III-A under the Factories Act, require such training. See Part 8 of Chapter-26.

4.3 Effects of Voltages :

For our 50 c/s electric supply, main danger limits of voltage are :

24 volts for children, and
60 volts for adults

In wet condition', these values decrease and depend on other factors also.

At 50 c/s (Hz), dry condition, the calculated electrical characteristics of human body are given in Table 11.4.

Table 11.4 : Electrical Parameters of Human body at 50 Hz, Dry Condition.

V volt	R ohm	I = V/R mA
12.5	16500	0.8
31.3	11000	2.84
62.5	6240	10
125	3530	35
250	2000	125
500	1130	443
1000	640	1560
2000	362	5525

This table indicates that as voltage increases, body resistance decreases and current increases. Body resistance becomes practically zero at high voltages.

Approximate threshold shock voltages at 50 c/s are as under:

Threshold of feeling	10 to 12 V
Threshold of pain	15 V
Threshold of severe pain	20 V
Threshold of hold-on	20 to 25 V
Threshold of death	40 to 50 V
Range of fibrillation	60 to 2000 V

4.4 Resistance of Skin :

Skin resistance for dry and wet condition are , shown in Table-11.5.

Table 11.5 : Human Resistance for various skin-contact conditions

Condition (Area to Suit)	Resistance, ohms	
	Dry	Wet
Skin	100-600 K	1 K
Finger touch	40 K-1 M	4-15 K
Hand holding wire	15-50 K	3-6 K
Finger-thumb grasp	10-30 K	2-5 K
Hand holding pliers	5-10 K	1-3 K
Palm touch	3-8 K	1-2 K
Hand around 1.5 inch pipe (or drill handle)	1-3 K	0.5-1.5 K
Two hands around 1.5 inch pipe	0.5- 1.5 K	250-750
Hand to Foot	400-600	
Hand immersed	-	200-750
Foot immersed	-	100-300
Human body, internal, excluding skin ohms	-	200-1000
Ear to Ear	100	

K= Kilo ohms M=Megaohms

Courtesy : Konwenlioven & Milnor

For example, dry skin of 100 kilo ohms resistance allows for 230 V mains,

$$I = \frac{E}{R} = \frac{230}{100000} \times 1000 = 2.3 \text{ mA current}$$

But when it is wet, it offers I kilo ohms resistance and allows

$$I = \frac{E}{R} = \frac{230}{1000} \times 1000 = 230 \text{ mA current}$$

i.e. 100 times more current.

Body resistance varies considerably from dry skin (hand) to damp skin (hand) and from low voltage (24 V) to mains voltage (230 V).

It is safe to assume a value of 500 ohms for dry work places and 200 ohms (or less) for persons working in wet places. Body resistance is practically zero at high voltages.

For females an4 children, the value of body resistance should be taken as half of that given in Table-11.5, and for DC the values of resistance should be considered 4 times that of AC for the same voltages.

4.5 Resistance of Materials :

Resistance values for equal areas (130 cm^2) c various materials are as under :

Material	Resistance, ohms
Rubber gloves or soles	More than 20 M
Dry concrete above grade	1-5 M
Dry concrete on grade	0.2-1 M

Leather sole, dry, including foot	0.1-0.5 M
Leather sole, damp, including foot	5 K- 20 K
Wet concrete on grade	1 K- 5 K

Note : K = Kilo ohms, M = Mega ohms.

4.6 Safe Distance from Electric Lines :

It is obvious that overhead electric lines should not be allowed in a place where the public or public vehicles have to pass through for most of the time and not at such a low or unsafe distance (clearance above ground) so that chances of touching the lines may increase. Therefore some minimum safe distance from lines are necessary.

Rules 77 to 80 of the Indian Electricity Rules, 1956 provide safety distances as given in Table 11.6.

Table 11.6: Safely Distances of Overhead Lines

Position of Lines		Minimum Distance Ft	Mt
Across the street :			
	Medium voltage lines	19	5.8
	High Voltage lines	20	6.1
Along the Street :			
	Low & Medium voltage lines	18	5.5
	High Voltage lines	19	5.8
Elsewhere :			
	Up to 11 KV lines, bare	15	4.6
	Up to 11 KV lines, insulated	13	4.0
	Above 11 KV lines,	17	5.2
	Above 33 KV lines,	17+1 For every 35 KV or part thereof	5.2+0.3 For every 33 KV or part thereof
Above 33 KV lines but across or along the street		20	6.1
Crossing the tramway or trolley wires :		Distance above the trolley wire	
Low & medium voltage lines		4	1.2
If the wire is insulated			
Up to 11 KV lines		6	1.8
Above 11 KV lines		8	2.5
Extra high voltage lines		10	3.0
Passing above, adjacent or terminating on buildings :			
(a)	Low & medium voltage lines -	10	3.0
	Vertical clearance	8	2.5
	Horizontal clearance	4	1.2
	For less clearance the wire should be insulated		
(b)	High & extra high voltage lines -		
	Vertical clearance :		
	Up to 33 KV Lines	12	3.7

	Above 33 KV Lines	12+1 For every 33 KV or path thereof	3.7+0.3
	Horizontal clearance :		
	Up to 11 KV lines	4	1.2
	Above 11 KV & up to 33 KV lines	6	2.0
	Above 33 KV lines	6+1 For every 33 KV or part thereof	2.0+0.3

Note : In above table, meaning of voltage range u/i 2fav) is as under :

Low voltage	Up to 250 V
Medium voltage	Up to 650 V
High voltage	Up to 33 KV
Extra high voltage	Above 33 KV

Where an overhead line crosses or is in proximity to another overhead line, minimum clearances between them are prescribed u/r 87(3) and given in Table-11.7

Table 11.7 : Clearances in metres between lines crossing each other

System Voltage	11-66 KV	110-132 KV	220 KV	400 KV	800 KV
Low & medium	2.44	3.05	4.58	5.49	7.94
11-66 KV	2.44	3.05	4.58	5.49	7.94
110-132 KV	3.05	3.05	4.58	5.49	7.94
220 KV	4.58	4.58	4.58	5.49	7.94
400 KV	5.49	5.49	5.49	5.49	7.94
800 KV	7.94	7.94	7.94	7.94	7.94

Minimum clearance should be maintained for are conductors or live parts or any apparatus in Outdoor sub-station, excluding overhead lines as given in Table-11.8 [Rule 64(2)(a)(ii)].

Table 11.8 : Minimum Clearance in meters

Highest System Voltage in KV not exceeding Ground clearance of 1000 mts.	Safety working clearance (mts.)
12	2.6
36	2.8
72.58	3.1
145	3.7
245	4.3
420	6.4
800	10.3

Note : A correction factor of 1.25% per 100 mtr. is to be applied for increasing clearance above 1000 mtr. and upto 3000 mtr.

Guarding arrangement shall be provided to guard against the possibility of lines coming into contact with each other. Every guard wire shall be earned at each point where electricity is broken.

Rules 79 to 88 of the Indian Electricity Rules, 1956 are also relevant.

Safety distances from high voltage lines are as under -

Line voltage - Horizontal distances on both the sides form the centre line of the tower or H frame.
66 KV > 9.5 mt
132 KV > 13.5 mt
220 KV r 17.5 mt

5 SAFETY MEASURES FOR ELECTRIC WORK

Statutory measures are already mentioned in foregoing Part-2 which must always be followed with the help of IS mentioned in Part-3 above.

Some general and main safety measures are stated below:

5.1 General Safety Measures :

They include

1. Proper earthing and double earthing. General earthing for big power station, upto 0.5 ohm,

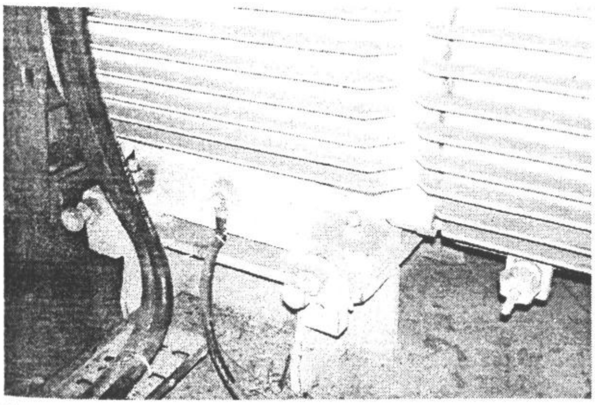


Fig 11.3 : Properly earthed electric motor.

   big substation 1 ohm, small substation 2 ohm and tower and other places up to 8 ohms. Due to minimum earthing resistance, leakage current passes through it and not through a person. The earthing should be inspected, tested and maintained properly. There should be a regular practice to check earthing. Minimum voltage between ground and the earthwire should be 30 V.
2. Use of approved insulated tools, rubber mats, shockproof gloves and boots, tester, fuse puller or tong, D.O. rod, discharge rod, safety belt, hand lamp, wooden or insulated ladder and not wearing metal ring, chain etc.
3. Switches on the live line. Fused switches and air-current breaks should be used.
4. Avoid temporary wiring. Avoid hurry and chance taking. Avoid left hand touching.
5. Employ qualified and trained electrician.
6. Low voltage (24 V AC or 110V DC) in hazardous area.
7. Good insulated and tested wiring.
8. Isolation of machine/equipment before use.

9. Work permit system as given in 18:5216-1969. Follow this IS for electrical work.
10. Safety tags and safety warning notices.
11. Use of m a chine/ equipment within their limits i.e. no overloading.
12. Placement of oil type transformer outdoor.
13. Auxiliary room, battery room and control room to be separated.
14. Two exits in each electric room.
15. Switch gear of the supply company should be separated from that of the consumer' by a fireproof wall.
16. Precautions against thermal and mechanical stress, moisture, dust and overvoltage. Automatic voltage regulators and overvoltage relays to protect from overvoltages.

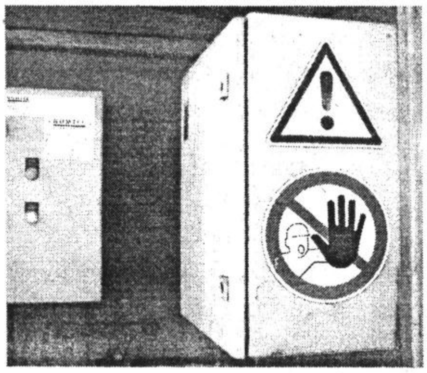


Fig 11.4 : 'Don't touch' Notice on high voltage electric Panel Board

17. Guard on transmission lines to prevent fault due to birds.
18. Verminproof enclosure for indoor switchgear. ?
19. Use of electric shock guard (ELCB) and 3-pin plug and socket to have proper earth connection.
20. Use of reactors or current limiting impendences or underground neutrals to reduce fault levels.
21. Use protective relays, circuit breakers and rated fuses to control the current and to isolate the faulty equipment speedily and automatically. Check before closing an OCB for high voltage lines.
22. Use of grounding mat of low ohmic value and all non current-carrying parts to be connected to the grounding grid by duplicate earth and segregated non current carrying metallic parts to be electrically bonded.
23. Record of ground resistance values and the physical condition of the grounding mat.
24. Temperature sensitive alarm and protective relays to make alert and disconnect equipment before overheating.
25. Interlocks to put into and out of service equipment correctly.
26. Testing for high voltage, timing, polarity and insulation resistance.
27. Cleaning and application of silicon grease to insulators to reduce pollution deposits.
28. Safe cable trenches and preferably armoured cables.
29. Transformers with oil safely, D.O. fuse, L.T. fuse, MCB, MCCB and automatic fire protection system.
30. Generators and motors with fire proof doors automatically actuated by fire detectors.
31. Ready CO, type and other fire extinguishers.
32. Double communication systems with critical areas.
33. Clear approach available for fire fighting squad.
34. Flame and shock detectors and central fire annunciation system for fire safety.
35. Diesel pump set for required fire water pressure.
36. Good housekeeping including well maintenance of all electrical installations.
37. Adequate working space and means of access around each apparatus.
38. First-aid boxes and respiratory equipment ready. Training for artificial respiration to save life from shock.
39. Prevent higher humidity and temperature near electric installations. Work with full protection in raining.
40. Use of flameproof/explosion proof equipment in flammable/explosive areas.
41. Earthing and bonding of solvent carrying pipelines and equipment.

5.2 Main Safety Measures :

They include -

1. **Isolation :** Live electric wires/parts should be kept out of reach from the normal working. Safety distances mentioned in Part 4.6 are one way of isolation. Cable trench is meant for isolation. Instead of providing transformers on ground level (this condition in industrial estates and on roads anywhere is most dangerous) they must be placed at a safe height with wire fencing. Provide segregation or a locked room if isolation is not possible. Circuit breakers and power isolation switches must be provided at appropriate places.

2. **Insulation :** Where isolation is not possible and electrical equipment or wiring are on the working level, cable, conductors and leads should be insulated with standard material. Double insulation means providing second layer of protective insulation. Then earthing is not required. Portable equipment like electric shavers, hair dryers, hand tools are of this type. Personal insulation means to protect the self by dry clothing, rubber shoes, rubber mat etc.

3. **Current limitation :** Only limited current should pass through the equipment. Excessive current should be stopped. This is done by providing fuses, circuit breaker or isolators. The size of the fuse is important. It should blow out when any short-circuit or earth current passes. A 5 amp fuse does not mean that it will blow at 5 amp. It only means that it is capable of carrying current of 5 amp continuously without getting hot. Generally fuses upto 10 amp rating are designed to blow at three times its rated value and those above 10 amp, at twice the rated value. Therefore, it is unsafe practice to tie a thick or more wires in a fuse. Then it may allow higher current, even more than the rated capacity of the equipment and damage it Switches may burn and become black. Low fuse value to limit current is the simpler and cheaper safety device.

4. Earthing : Proper earthing is equally important as fuses. If an equipment is properly earthed, the higher earth (fault or short circuit) current will pass through the fuse or circuit breaker to the earth. This will open the circuit to protect the equipment. Earth conductor should be checker frequently for continuity and tightened if founds loose. Maximum permissible earth resistance ft different fuse sizes are as under:

Fuse Amp	Earth resistance in ohm (max)
5	15.3
10	7.6
20	5.7
30	3.8
60	1.9
100	1.1
200	0.59

Thus earth resistance should be regularly checked and maintained as per requirement.

5. **Other Precautions :** These include sufficient working space, means of access, proper lighting, use of PPE, FFE, avoidance of loose, broken or open wiring, contact of metal parts and trained and competent personnel. While working on live conductor or equipment full sleeves are more useful as dry cloth gives some protection against shock. Don't wear or keep any metallic ornament or metallic part on body.

6 OVERLOAD AND OTHER PROTECTIONS

In industrial buildings, appropriate protection at switch-boards and distribution boards for all circuits and sub-circuits against over current and earth faults is necessary. The protective apparatus should be capable of interrupting any short-circuit current that may occur, without danger. The ratings and settings' of fuses and the protective devices shall be coordinated so as to afford selectivity in operation where necessary. Setting of HRC fuses should be proper. Supply of electric lighting and emergency services should be through separate main service and distribution boards from the power circuits.

Majority of electrical accidents can be avoided if (1) Live parts are insulated in effective and durable manner and positioned safely (2) Conductive parts of the equipment or machines should be earthed or double insulated and (3) All components must be so dimensioned as to withstand design stresses

6.1 Power Cutting Devices (Means of Cutting of Power):

These are switches, switch with' fuses, isolating links or circuit breakers. Where rapid operation is required, switch fuses and isolating links are not suitable. Separate switches should be provided to transformers, motors and apparatus at convenient places. For motors, switches should be close to the starters. Locking arrangement on switch or starter prevents accidental starting. If locking is .not possible, fuses should be taken out while working on that line. Earthing of conductors, particularly of high voltage or overhead lines, is necessary. Mechanical devices are clutches and belt striking gears.

Restriction on use of Switch on Neutral Earthed Conductor:

A single pole switch should not be placed in the neutral conductor of a system which is connected to earth (except for special purposes in generating stations).

If this conductor is bare, even double pole switch should not be placed in this conductor except for the purpose of breaking connection with generators and transformers supplying the power. But the connection with earth should not thereby be broken.

Important Safety Requirements in Design and Use of Switches, Switch-Fuses, Circuit-Breakers and Isolating Links.

1. Sufficient capacity for making and breaking contacts.
2. Cover for switch.
3. Handle spindle should be a close fit in die hole in order to prevent injury from arcs inside. Handle should be insulated.
4. "On" and "Off" position in switches and circuit breakers should be clearly marked.
5. Ample space between opposite poles of double and multi-pole air break switches and circuit-breakers.
6. They should make and maintain good contact on being operated without any special skill or manipu lation.
7. Switches and circuit-breakers should be of such construction that they cannot be left in partial contact, that there is speedy breaking of contact, when operated to off position. There should also be other extra means of controlling the arc where necessary.
8. Handle should be of sufficient size consistent with the effort required to operate. It should be insulated and earthed.
9. Isolating links and switches without insulated handles should be operated by safe means such as by insulated poles.

6.2 Types of Protections :

6.2.1 Capacity and Protection of Conductors, points and Connectors :

All apparatus and conductors should be of sufficient size and strength. They should be covered with insulating material and placed or enclosed as to prevent danger, viz. (a) Conductors in conduit (b) Conductors in flexible metallic tubing (c) Conductors in metal trunking (d) Conductors with metal sheeting (e) Insulated cables like V.I.R. and C.S.T. Cables (f) cables in trench.

Overhead trolley wires of cranes should be (1) either protected by screen guards with suitable opening for tapping, or (2) insulated cable self-winding drums should be used.

Screw cap lamp holders in which the screw position of the holder and the lamp cap are conductive, should be fitted with suitable shrouds or skirts or protected in any other suitable way.

Electrical joints and connections should be (proper construction as regards conductivity, insulatiol mechanical strength and protection.

6.2.2 Overload and Short Circuit Protection

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Danger from exces I current due t< I overload or short I circuit should bi i prevented b7

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operation of protective gear is not caused.

Fuses, relays and circuit-breakers should be of sufficient breaking capacity to operate safely at short circuit currents. Arcing or scattering of hot metal of fuses may be prevented by the use of improved fuses of cartridge or other type having special arrangements for extinction of arc at reduced current values.

Safety in Renewal of Fuses or Fusing elements

1. Operation Without Switching Off : Here switchfuses are used. For heavy current circuits, switches should be provided and operated before operating the fuses.

2. Operation After Switching Off : This is the safest and should be the general practice. Requirements are : (a) Interlocking with switch (b) Independent switches to be accessible (c) Combined switch and fuse boxes should have live parts shrouded or protected.

Circuit-breakers where short circuit current exceeds 10000 amperes or 150 MVA should not be direct hand-operated.

Thermal Protection : Thermal fuses and relays, operating on temperature rise are suitable for use with circuit or appliances where the fault current does not exceed the load current "or where small overloads can cause burn out.

Examples are : (1) Choke coils of fluorescent tubes (2) Fractional horsepower motors (3) Radio sets.

Equipment such as motors which require heavy starting currents can be effectively protected by thermal relays.

6.2.3 Earth Fault Protection :

Protective Earthing:

All non-current carrying metal parts of electrical equipment, should be earthed. Such parts are : (1) Metal conduits, bus bar, steel trunking and cable sheets (2) Non-current carrying metal parts of (a) Switchgear, fuse and starters (b) Generators and motors (c) Lighting fittings and (d) Other electrical equipment or appliances.

To earth is to connect to the general mass of earth in such a manner as will ensure at all times an immediate discharge of electrical energy without danger and to allow sufficient current to flow to blow fuses or operate protective devices and thereby

. disconnect faulty apparatus.

Good earthing can be achieved by connecting earth continuity conductor to :

1. Sheath and armour of "supply" cable whenever available.
2. In the case of supply from own transformer to a heavy section copper wire running to the neutral point of the transformers, and 3. Neutral wire where "protective multiple earthing" is allowed and adopted.

In the absence of these, connection should be made to earth electrode or electrodes having low resistance to earth.

Connection between earth lead and earth electrode should be made wherever possible above the ground for facilitating inspection. Joints involving dissimilar metals should be avoided. All joints should be treated with a conducting paint.

In all cases the earth continuity conductors should have sufficient current carrying capacity to take the fault current safely till the fuse or the circuit breaker blows or trips. The total impedance from any point in the system to the earthing point and through it to die general mass of -earth and then to the neutral point of the supply substation transformer and back to the fault point through the line conductor should be as small as possible (4 ohms for 15 A fuse and I ohm for 60 A fuse for voltage 240 V). Wherever conduits and sheaths are used as earth continuity conductors (without separate earth wire) earth continuity should be ensured at joints and junctions by suitable connections.

Earthing of Electrically Driven Machine Tools :

The bed plates of all mad-lines should be earthed with copper conductor of adequate size. Each control gear casing such as starters etc., should be connected to the bed plate. Where the motor is movable on the machine and hence does not make proper contact with the bed plate, flexible copper wire should be provided

Electrical joints and connections should be proper construction as regards conductivity, insulation, mechanical strength and protection.

6.2.2 Overload and Short Circuit Protection :

Danger from excess current due to overload or short-circuit should be prevented by providing (1) Fuses (2) Circuit-breakers or (3) Thermal protection.

Protective apparatus should be set at a low current protection are introduced as in the case of motors etc., possible excessive temperature rise in equipment and conductors should be considered. The number of item: collectively protected should be limited to avoid overfusing to withstand .heavy switching currents anc to ensure subdivisions so that inconvenience from operation of protective gear is not caused.

Fuses, relays and circuit-breakers should be of sufficient breaking capacity to operate safely at short circuit currents. Arcing or scattering of hot metal of fuses may be prevented by the use of improved fuses of cartridge or other type having special arrangements for extinction of arc at reduced current values.

Safety in Renewal of Fuses or Fusing elements

1. Operation Without Switching Off : Here switch-fuses are used. For heavy current circuits, switches should be provided and operated before operating the fuses.

2. Operation After Switching Off : This is the safest and should be the general practice. Requirements are : (a) Interlocking with switch (b) Independent switches to be accessible (c) Combined switch and fuse boxes should have live parts shrouded or protected.

Circuit-breakers where short circuit current exceeds 10000 amperes or 150 MVA should not be direct hand-operated.

Thermal Protection : Thermal fuses and relays, operating on temperature rise are suitable for use with circuit or appliances where the fault current does not exceed the load current "or where small overloads can cause burn out.

Examples are : (1) Choke coils of fluorescent tubes (2) Fractional horsepower motors (3) Radio sets.

Equipment such as motors which require heavy starting currents can be effectively protected by thermal relays.

6.2.3 Earth Fault Protection :

Protective Earthing:

All non-current carrying metal parts of electrical equipment, should be earthed. Such parts are : (1) Metal conduits, bus bar, steel trunking and cable sheets (2) Non-current carrying metal parts of (a) Switchgear, fuse and starters (b) Generators and motors (c) Lighting fittings and (d) Other electrical equipment or appliances.

To earth is to connect to the general mass of earth in such a manner as will ensure at all times an immediate discharge of electrical energy without danger and to allow sufficient current to flow to blow fuses or operate protective devices and thereby disconnect faulty apparatus.

Good earthing can be achieved by connecting earth continuity conductor to :

1. Sheath and armour of "supply" cable whenever available.
2. In the case of supply from own transformer to a heavy section copper wire running to the neutral point of the transformers, and
3. Neutral wire where "protective multiple earthing" is allowed and adopted.

In the absence of these, connection should be made to earth electrode or electrodes having low resistance to earth.

Connection between earth lead and earth electrode should be made wherever possible above the ground for facilitating inspection. Joints involving dissimilar metals should be avoided. All joints should be treated with a conducting paint.

In all cases the earth continuity conductors should have sufficient current carrying capacity to take the fault current safely till the fuse or the circuit breaker blows or trips. The total impedance from any point in the system to the earthing point and through it to die general mass of -earth and then to the neutral point of the supply substation transformer and back to the fault point through the line conductor should be as small as possible (4 ohms for 15 A fuse and I ohm for 60 A fuse for voltage 240 V). Wherever conduits and sheaths are used as earth continuity conductors (without separate earth wire) earth continuity should be ensured at joints and junctions by suitable connections.

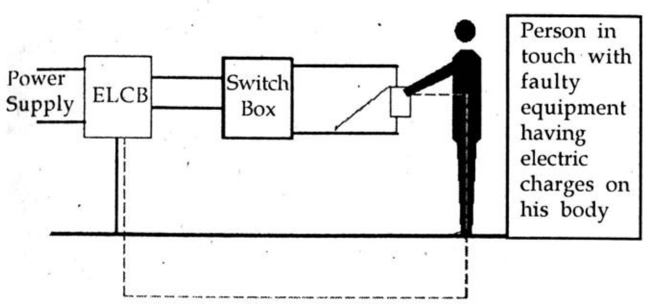
Earthing of Electrically Driven Machine Tools :

The bed plates of all mad-lines should be earthed with copper conductor of adequate size. Each control gear casing such as starters etc., should be connected to the bed plate. Where the motor is movable on the machine and hence does not make proper contact with the bed plate, flexible copper wire should be provided to connect the motor and the bed plate. In bed plates and control gear casing, separate terminals should be provided for earthing. Flexible metal tubes used to protect wiring at motors should not be used as earth conductor, but a separate earth conductor should be run within it.

Portable power tools (hand-held electric drills, grinder, cutter etc.) must also be earthed or double insulated, otherwise fault current gives a severe shock. For details see Part 7.

Earth Leakage Circuit-Breakers (ELCB) :

Where it is not practicable to obtain low impedance or where protection afforded by the over current fuses and circuit breakers along with the earthed, conductors is not adequate, leakage protection can be achieved by: (1) Voltage-operated earth leakage circuit-breakers (2) Differential current circuit-breakers or (3) Combined voltage-operated and differential current circuit-breaker. The current operated ELCB operates even at 0.5 amp current and reduces fire risk. For further safety special 4 pin plug and socket and a 4 core flexible cord arc available.



If an earth leakage circuit breaker (ELCB) is provided, it will operate due to rise in earth voltage or current and open the circuit as fuse opens. This will stop the current towards equipment or machine, it will be de-energised and its contact will become safe..

Relays are utilised to actuate at pre-set threshold voltage or current and to isolate the appliance in which the dangerous condition has developed.

6.2.4 No Load Protection :

Over current condition is generally known as 'overload' condition. It should be protected by equipment which will operate at excess (more than rated) current and stop the supply. Similarly low current or low voltage condition is said to be 'no-load' condition and it also needs to be protected. Simple running of an electric motor without rotating the pump, generator or machine shaft, is known as no-load working. It draws minimum current depending on winding resistance. With the same resistance, if the voltage is reduced, it will reduce the current. In such condition, the use of fuses as a tripping device is generally preferred.

In low voltage system if the circuit is direct current type or heavily loaded, the slow operation of fuses (low current) often results, in arcing or flashover followed by burning of the contacts and this is dangerous for service personnel. Therefore they should be protected by following measures.

1. Employ trained electricians and give them full information regarding possibility of arcing from fuses.

2. Handles of the switch or fuse-box should be insulated. Leather, hand-gloves (up to elbow) should be given to workers.

3. No load protection and protection against accidental contact are also necessary. At no load, no more current is desired. Therefore low current rated fuses are to be selected. .

4. Fuse box cover should have small aperture to introduce the end of a voltage tester to ensure that the contacts are live or not. The box (flashproof) cover should be such that when it is opened, it will stop the current.

6.2.5 Earth, Insulation and Continuity Tests:

When electric current passes through its expected resistance (load) path, its energy is utilised in heating, rotating or doing the required function. But when due to insulation failure, breaking, opening or loosening of conductor or directly touching to any metal part, tool or a human body, the current passes through the line of least resistance i.e. instead of passing through its regular machine or equipment circuit, it jumps (diverts) to the metal part or human body and tries to flow through the lowest resistance to the lowest potential. Now the earth has an extremely low electrical resistance and practically zero voltage, the leaking current (i.e. earth or fault current) tends to flow through the metal part or the human body to the earth if they are touching the earth. If the human body is separated or insulated from the earth by insulating material like rubber gloves, rubber shoes, rubber mat, wood etc., the current will not flow through the body and the shock can be avoided. Similarly metallic exposed part if not earthed, will remain live and if some one touches it or metal contact between the exposed part and the earth is available, the current will flow to the earth.

Therefore from safety point of view, if metal part of the equipment, machine, vessel, structure, pipe etc. are, in advance, properly earned i.e., connected by an earthing conductor to the earth pit of low resistance, accidental earth fault current will flow through it. Supply voltage being die same and the resistance being reduced, the current will increase due to E=IR. This heavy current when passes through the fuse, it melts and the circuit becomes open.

Besides earth tests, it is also necessary to carry out insulation and continuity tests of installations and apparatus at periodical intervals. This is necessary to ensure that insulation values are within safe limits and that there is continuity of the circuit without excessive leaks. These can be carried out easily with special type of instruments.

Thus earth, insulation and continuity are considered for-safety purposes and they should -be tested for protection. If insulation breaks, live conductor or a metal part is exposed and it is danger. If continuity of a conductor is broken from inside, supply side is energised but not known and may cause hazard. While the other side is broken, the equipment does not work due to discontinuity. If the earth conductor is discontinued, it is like 'no earthing' and poses great hazard. Therefore continuity of earthing conductor is most important.

In earthing system, neutral conductor of the distribution power system is connected to earth at many places by parallel conductors. This system is known as Multiple Earthed Neutral (MEN) or Protective Multiple Earthing (PME) system. This system has the widespread use in the world.

Earth resistance should be kept low to keep the earth temperature low. Therefore earth resistance should be periodically checked and maintained.

Insulation and continuity tests are necessary to ensure that insulation values are within safe limits and the circuit is continuous (unbroken) and without excessive leaks. Instruments are available for such tests.

6.2.6 Earthing Standards :

IS:3043, Code of Practice for Earthing and SP 30 National Elective Code must be referred for details of earthing.

Earthing means a low impedance return path of the fault current. Actually the earth, now, rarely serves as a part of the return circuit but is being used mainly for fixing the voltage of system neutrals. The earth connection improves service continuity and avoids damage to equipment and danger to human lives.

Earthing of current carrying conductor is known as system earthing, while that of non-current carrying conductor or metal work is known as equipment earthing. The former is essential to the security of the system and the latter to the safety of persons, property and animals.

Following is the synopsis of earthing standards mentioned in Section 12, Part I of our National Electric Code:

1. The purpose of system earthing is to preserve the security of the system. There should be two separate and distinct connections with earth through an earth electrode.

2. The earth system resistance should be such that the fault should operate the protective gear (fuses or circuit breaker) to isolate the faulty portion.

3. The purpose of equipment earthing is to protect the equipment from danger to life or risk of fire due to leakage of current through the metal work and through the person in contact. The leaking current operates the protective gear due to earthing.

4. In case of high and extra high voltages, the neutral points shall be earthed by two or more separate electrodes.

5. Earth electrodes shall be provided at generating stations, substations and consumer premises as per requirements.

6. As far as possible all earth terminals should be visible. The connections should be adequate and tight.

7. Normally the earth system resistance should be less than 1 ohm, unless otherwise specified. Testing of earth electrode should be possible.

8. The current carrying capacity of the system should not be increased so as to increase the earth fault current or its duration to make the earthing in-capable of bearing new value.

9. All materials, fittings etc. used in earthing should conform to Indian Standard.

10. Design of earth electrode dimensions should consider electrical resistivity of the soil. The earth conductivity depends or moisture content of the soil, salts in the water, chemical composition, grain size and distribution etc. These factors vary locally and some seasonally. Local values should be verified by actual measurement.

11. The step potential and touch potential should be measured and kept within safe limits.

12. The size of earth-continuity conductors should be correlated with the size of the current carrying conductors. The sizes of the earth-continuity conductors should be more than half of the largest current carrying conductors. The range of earth-continuity conductors should be as under:

Material	**Min**	**Size**	**Max**	**Size**
Copper	1.5	mm^2	70	mm^2
Aluminium	2.5	mm^2	120	mm^2

13. Earthing of electrically driven- machine tools should be as under :

Material	**Strip or Conductor size (min)**
Copper	$6.5mm^2$
Aluminium	$10\ mm^2$
Steel or GI	$16\ mm^2$

The bed plate should be securely fastened by a bolt.

14. Earthing of portable appliance and tools should be continuous i.e. no twisted or taped joint should be used in earth wires. A single pole switch should not be connected in earth conductor. Fixed wiring at appliance inlet terminals must be done correctly and as per IS Appliance having double or reinforcement insulation need not be earthed.

15. Following rules of the Indian Electricity Rule; 1956 are relevant on earthing standards :

Rule Subject

32	Identification of earth conductors.
33	Earthed terminal on consumer’s premises.
51	Provisions for power installations.
61	Connections with earth.
61 A	Earth leakage protective device.
62	System at medium voltage.
67	Connection with earth.
69	Pole type substations.
88 (2)	Guarding.
90	Earthing.

6.2.7 Protection against Surges and Voltage Fluctuation:

When equipment is switched on, momentarily initial excessive currents are known as current surges or transient current.

Surges may be more in starting cold circuits than the hot circuit i.e. restarting of the previously live circuit which was closed for a short while. For example, when large banks of filament lamps are switched on, current surge arises, because they have, much lower resistance when cold than when hot. If a live lamp circuit is made off and soon reenergised, it will face fewer surges. Therefore fuse or circuit breaker rating should consider this surge phenomenon or its effect given as Pt where I = current, t = time and [Ft] known as pre-arcing of a fuse or let through of a fuse or circuit breaker or withstand of a component e.g. diode.

Current surges are also produced when large banks of condensers are switched on. For example if the condensers have retained a charge of the reverse polarity and its circuit is energised at the moment of maximum voltage, a very large charging current will flow. When condensers are switched for power factor correction or tuning on high frequency furnace installations, high surge current flows. To prevent damage, large HRC fuses are sometimes placed between sections.

Switching large power transformers or starting up motors driving high inertia loads, also cause large current surges if closure occurs near maximum voltage. H is therefore important to ensure that the motor and starter are both suited to the duty. Failure to do this may cause the motor to burn out or the starter to explode.

During surge current, [Pt] denotes a measure of the damage or the specific energy of the operation and can be defined as the energy dissipated as heat during a specified operation per ohm of resistance. Therefore for protection against surges, values of the protecting device should withstand [Pt] value. This can be dealt with in the light of experience by increasing settings and fuse sizes. It does, however, militate or resist against close protection.

Voltage fluctuation from the electricity supply lines has become a common phenomenon at many places. Supply voltage goes down resulting in reducing speeds of fans, motors, machines etc. and reducing lamp lighting. Again it comes and stabilises the condition. Such voltage fluctuation, if on higher side, may blow fuses or protection and if on lower side, reduces the productivity or effect of equipment.

Automatic voltage regulator or voltage stabiliser, either built-in with the equipment (mostly with household appliances like freeze, TV etc.) or external are readily available.

Voltage fluctuation on either side is harmful. It 'accelerates or decelerates speed of machine or production. It damages furnaces by over or under heating. It increases or decreases lighting, ventilation, voice etc. and many power dependent parameters. Change in temperature affects reaction rate in chemical processes. It affects radio, TV, computer, hand tools and many home appliances. Over voltage causes over current which may increase the intensity of shock and flashover. Electric motors, fuses, starters, switches, wiring, insulation may burn due to over voltage and overheating. Therefore over voltage or under voltage must be prevented by appropriate automatic voltage regulators or by power cutting devices. See part 6 for overload and other protections.

Travelling voltage surges may become weaker by surge absorbers which are designed to dissipate energy by eddy currents and/or hysteresis loss or by a sufficient length of cable. Over-voltages can be relieved by spark gaps or by various devices which are insulators at normal voltages but breakdown at a prescribed over-voltage. They may or may not be 'self healing'.

Voltage spikes caused by current chopping may be avoided by a proper choice of cartridge fuses and others suppressed by shunt connected silicon or other semi-conductors for power circuits and zener diodes for light current circuits.

The possibility of flash over in high voltage trifurcating boxes on transformer, switchgear or motors is prevented by better insulation, filling techniques and/or phase separation.

Disconnected overhead line in the proximity of other overhead lines, should also be kept earthed, otherwise it may cause shock due to voltage induced in it.

6.2.8 Hazards of Borrowed Neutrals :

Now-a-days mostly the 4-wire, multi-grounded, common-neutral distribution system is used exclusively because of their economic and operating advantages. In a star system the neutral point is solidly grounded. Sometimes a small amount of impedence is inserted between the transformer neutral and ground in order to limit line-to-ground short-circuit currents on the primary system to a predetermined value.

The neutral circuit must be a continuous metallic path along the primary routes of the feeder and to every user location. Where primary and secondary (single phase) systems are both present, the same conductor is used as the common neutral for both systems.

The neutral is grounded at each distribution transformer, at frequent intervals where no transformers are connected and to metallic water pipes or driven grounds at each user's service entrance.

The neutral carries a portion of the unbalanced or residual load currents for both the primary and secondary systems. The remainder of this current flows in the earth. Ground electrode should have a resistance less than 25 ohms.

Where there is no secondary neutral and no distribution transformers, the primary neutral should be grounded at intervals of 500 to 1000 ft. By a direct buried, concentric neutral cable, the excellent grounding is obtained.

Hazard arises when there is a discontinuity in the neutral path. Therefore no disconnecting devices should be installed in the common neutral. In no case, the earth or buried metallic piping system should be used as the only path for the return of normal load current.

In borrowing of neutral by tapping or otherwise, hazards arise if the size of the neutral conductor is changed in new line or any discontinuity is left somewhere or if that line becomes the return path of normal load current.

In a 3-phase balanced primary circuit, the neutral conductor can be of a smaller size than the phase conductor, but in a single-phase primary circuit (phase and neutral), the neutral conductor should be large enough to carry almost as much current as the phase conductor. Mostly the same conductor size should be used for both, the phase and the neutral to avoid the hazard.

6.2.9. Lockout and Tag-out :

Lockout and Tag out are generally industrial practices indicating 'warning' that the equipment or machine so locked or tagged out shall not be used till that lock or notice is removed.

Lockout means making the equipment / machine inoperative or power - isolated so that it cannot be started or used. Locked label or notice of 'Lockout' indicates that this equipment or machine is faulty, under repair or-maintenance and is locked for the purpose of not using it till this lock or notice exists.

Tag-out means to tie a tag on the equipment or machine to indicate that it is under repair or maintenance and not to be touched or used. Tag out is most essential when lockout is not possible. It can be used in addition to lockout for further precaution.

Lockout and Tag out procedure is also required to prevent accident from unexpected starting or operation of any switch, starter, motor,, equipment etc. .When some repair or maintenance work is to be started on electric line or some vessel, pipe line etc, source of supply of power, energy, flow etc needs to be isolated and for this purpose, such switch, lever, valve, control knob etc should be kept in locked off position by positive locking and tagging indicating instruction not to open the lock or operate that switch, valve etc.

When more than one department wants lockout of the same switch, valve, equipment etc, each of them should apply their own lock and tagging. In such multiple locking, each key should be different and no master keying should be available. In case of difficulty, lock may be broken down but no duplicate key should be available.

Procedure of lock out should be established. It should include

1. Before locking or tagging, inform the concerned operators and users that line, switch, valve or equipment will be isolated or de-energized and give them time to complete or stop their work.
2. Plan the shut down and make the system off.
3. Insert lock and attach tagging.
4. Test that the isolation is positive and as, per expectation.
5. When repair / maintenance work is over, open the locking and tagging.
6. Again inform the concerned people that locking / tagging is removed and they can work as usual.

6.3 Lightning Arrester :

Purpose of lightning arrester is to attract lightning from the sky and to bypass it into the ground and not allowing it to pass through any combustible material.

A pole type long rod of good conductor is attached on the tallest structure at site. Because of its good conductivity (low electrical resistance) electrical current of the lightning is directly passed into the earth it is necessary to check its continuity and resistance of the lightning arrester at regular interval.

It is not desirable to attach lightning arrester directly on the metal tank of flammable liquid or gas because in case of unknown discontinuity, lightning may pass through the metal surface and the whole tank may trap in to the fire.

IS : 2309 and 4850 are useful in this regard.

7 PORTABLE ELECTRICAL APPARATUS

Portable electrical apparatus have caused many accidents. Metal-cased apparatus is often held firmly in the hand by person whose foot usually make good contact with floor or metal work. The flexible cables are subject to much bending, rubbing and hard use. The appliances or tools are subjected to vibration and rough treatment in use. In those circumstances special precautions are required in installation, maintenance and use of portable apparatus.

See Part 4 of Chapter-17 for hazards and safe use of portable power tools.

Cable and Connections : Portable apparatus to the system should have efficient permanent joints, connections or connectors.

The cable should be reinforced at the place where it enters the plug with stout rubber tubing or metallic spiral. The cable grip should be such that outer covering or sheathing is securely held and no strain is placed on conductors. Hand shield, disc or other types of guard between grip or handle part and the portion containing cable and contact pins should be provided. Three pin protective plug and socket should be used.

Earthing Insulation : All non-current carrying metal parts of portable apparatus and pendant lamps should be earthed unless suitably covered with insulating material. The flexible metal covering of conductors should also be earthed; but it should not be the means of earthing the portable apparatus, as the resistance of such metallic covers are high.

Lamp holders of portable lamps should not be in metallic contact with the guard or other metal work. They should be insulated and the other metal parts earthed. For use near live conductors, hand lamps having completely insulated exterior and guards should be used.

For use in dangerous situations such as inside of boilers or tanks or damp and exposed positions, low voltage lamps or tools should be used. A pressure of 24 volts with 12 volts to earth is recommended.

Earthing resistance should be checked frequently and wherever it is difficult to obtain a low resistance, other methods of earth fault protection described earlier (e.g. ELCB) should be used in addition. Systems having monitoring current which will trip the supply if there is break in the earth connection or if the resistance is high, provide adequate protection.

See Part 6.2.6 and its para-14 & 15 for earthing of portable appliances.

Portable Transformers : The main hazard with metal cased portable transformers is that if the earth wire becomes detached in the mains-plug and touches live wire, the secondary neutral and the metal case will praised to phase voltage of the mains. The apparatus will thereby be charged to phase potential. The remedies are : (1) Constant inspection (2) Provision of "stations" with two separate earthed sockets, one for mains supply from the transformer (3) Transformer with insulated casing.

Portable apparatus operating at low voltage (e.g. 110 V) are more safe than those operating at higher voltage.

8 ELECTRIC WORK IN HAZARDOUS ATMOSPHERE

8.1 Classification of Hazardous Areas :

In chemical, petrochemical, refinery and fertiliser factories and also in coal mines, combustible/explosive dust, vapour and gases may evolve during normal or abnormal operating conditions.

These gases coming into contact with air make an explosive air-gas mixture which is hazardous to the installation of electrical apparatus as well as to the workers.

IS'.5572 divides the hazardous area (containing flammable gas or vapour capable to be ignited) into following three zones for the purpose of appropriate electrical installation :

Zone 0 Areas : Here hazardous atmosphere exists continuously viz., the vapour space of closed process vessels, storage tanks or closed containers. Any spark will certainly lead to fire or explosion. Therefore, any electrical apparatus in this zone must afford an absolute protection. It is recommended that the use of electrical apparatus should be avoided in this zone, but when it is not practicable, IS:5571 (Guide for selection of electrical equipment for hazardous areas) should be followed.

Zone 1 Areas : Here hazardous atmosphere is likely to exist at any time. Therefore the fullest practicable measures should be applied to prevent a hazardous electrical condition at any time and in any circumstances. Recommended types of electrical apparatus and wiring for use in Zone I areas are given in IS:5571.

Zone 2 Areas : Here hazardous atmosphere is likely to occur only under abnormal operating conditions. This classification is applicable only where a fire or explosion hazard is unlikely and may be caused only by the simultaneous and improbable occurrence of an arc or spark resulting from an electrical failure and a hazardous atmosphere arising through failure of the conditions of control. It presupposes that any hazardous atmosphere resulting from an abnormal occurrence is rapidly dispersed so that possible contact with the electrical apparatus is of minimum duration. Any situation which allows a hazardous atmosphere to collect, such as pit or trench, although, it may be in the open air, shall in itself be classified as Zone I area, even though the surrounding area is classified as Zone 2. Where doubts exist in any specific case, a Zone I classification should be adopted.

8.2. Flameproof Electrical Equipment :

The types of protection generally applicable to electric motors for use in hazardous areas are:

1. Flameproof or Explosion proof, Type-d
2. Increased Safety, Type-e
3. Intrinsic Safety, Type-i
4. Non-Sparking, Type-n
5. Pressurised, Type-

IS:5571 guides us for selection of electrical equipment (motors, transformers and capacitors, lighting fittings, switchgear and control-gear) for hazardous areas. IS:2148 gives specification for flameproof enclosures of electrical apparatus and IS:4691 for degrees of protection provided by enclosures for rotating electrical machinery. IS 4012 for dustproof electrical lighting fitting, 2206 (Part I to 4) for flameproof electric lighting fittings, 8945 for electrical measuring instruments -for explosive gas atmosphere, 7118 for direction of movement for control devices operating electrical apparatus and 7689 for control of undesirable static electricity are also relevant.

In Zone-1 area flameproof or pressurised type motors whereas in Zone-2, increased safety type motors are suitable. Table 11.9 gives summary :

Table : 11.9 Types of motor protection in hazardous areas:

Type of Protection of Motor	Symbol	Hazardous Zone	Advantages	Disadvantages	IS
Flame-proof	d	1,2	Robust, permits maintenance of internal equipment	Expensive in larger sizes. Difficult to weather proof. Careful maintenance	2148 3682
Increased Safety	E	2	Cheaper, Suitable for all gases Long Life.	Requires careful installation	6381
Non Sparking	N	2	Cheap	Some designs difficult to maintain	8289
Pressurised	P	1,2	Safe, suitable for all gases. Can be modified and maintained	Auxiliary equipment needed to provide dry air on inert gas	7389

For flameproof enclosures, gases and vapours are classified according to their Maximum Experimental Safe Group (MESG). The groups of apparatus are Group I for mining application (methane) and Group II for application in other industries. Group II is subdivided as IIA, UB and IIC. Similarly, gases and vapours are also classified in the same four groups according to the ratios of their Minimum Ignition Currents (MIC) with that of laboratory methane. Table-3 in IS:2148 suggests these four groups for particular gas or vapour, for example, Group I for methane, IIA for ammonia, benzene, acetone, methanoi etc., IIB for ethylene, ethylene oxide etc., and IIC for hydrogen.

Testing of electrical equipment for use in explosive atmosphere is most essential.

Available flameproof equipment include motor, transformer, switch socket, switchgear, limit switches, push buttons, rotary cam operated switches (isolators), switch fuse unit with HRC fuse links, electric bell, fluorescent tube light fixture, wall glass lighting fitting, flood light, control gear box, bulkhead fittings, hand lamp, vessel lamp, safety torch, indicating lamp, ammeter, measuring instrument enclosure, moulded case circuit breaker, distribution board, control station, remote control panels, junction boxes, meter boxes, cable glands and accessories.

ISI mark must be preferred. Rules for installation and maintenance of transformer substation, main switch boards, distribution boards, conduit wiring system, cable wiring, lighting layout, earthing and lighting protection and inspection and testing should be strictly followed for their safe working in flammable/explosive environment. This is statutory requirement also as stated earlier.

8.3 Safety Measures with Low & High Risks Areas :

In low risk area, following Safety measures are necessary

1. Segregation of equipment that may generate heat or spark. For example, fuses, switchboard, transformers, motor, resistance, heater etc. should the segregated. For Rules of segregation, see TAC booklet published by Bombay Regional Tarrif Advisiory Committee.
2. Guarding, insulation and protection of conductors.
3. Earthing of all metal work.
4. Less operation of switches and starters to avoid spark.
5. Covering heaters and resistance to prevent contact with hot surfaces.
6. Interlock switch to ensure making and breaking of connectors with switch in off position.

In high risk area, following safety measures are necessary.

l. Electrical equipment should be flameproof and of the approved type.
2. Pressurised electrical equipment.
3. Intrinsically safe electrical equipment.
4. Segregation of the electrical equipment to the extent possible.
5. Overload, short circuit and leakage protection with close setting up of fuses or overload protective devices.

Besides fire fighting equipment, following fire safety requirements are also recommended :

1.	Area up to 750 m^2	-	Automatic fire alarm system
2.	Area above 750 m^2	-	As above or automatic sprinkler

Refer Part 3.3. for TAC regulations

9 STATIC ELECTRICITY

9.1 Electrostatic Charges & is charges:

Importance of static electricity is increasing with the increasing use of insulating plastic, rubber, chemicals, petrochemicals, films and flammable gases, vapours and dusts.

The generation of static electricity is a surface phenomenon associated with the contact and separation of dissimilar surfaces. Friction is not necessary to generate electrostatic charge, however it increases the release of electrons and production of ionised particles. Conditions necessary for generation of static electricity are :

1. A means of electrostatic charge generation.
2. A means of accumulating the generated (separate) charges and maintaining a potential difference.
3. There must be discharge of the accumulated charge to give sensation or effect of the static electricity. If the discharge i.e. separation is o adequate energy, it will give a spark (which can ignite a flammable mixture).

Thus, static charge is first generated, then accumulated and lastly discharged. Out of these three stages, only last one is visible.

Static charge may occur due to :

1. Contact charging by two dissimilar materials in contact. Plastic films passing over metal rollers (which should be earthed), powders flowing through duct or people walking over carpets may become highly charged.

2. Liquid flow through pipes generates charge due to adsorption of impurity ions. This may readily occur when filters are used with petroleum products.

3. Spray Electrification. Fragmentation of a liquid surface produces charged droplets. Splash-filling of a tank may form a charged mist. In a tanker, incendive sparks may come from charged clouds generated by water sprays for cleaning. Steam-leak also produces charge on isolated metal work viz. nearby pipeline. CO_2 discharge from a fire-extinguisher, may also generate charge.

4. Corona charging. Xerographic copying and electrostatic paint or powder spraying creates charge by air ions.

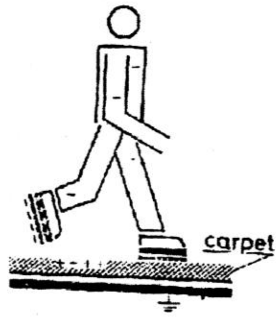
5. Induction charging. Nearby charge raises the potential of an isolated conductor. This may concentrate electric fields and initiate sparking. The electrical energy of a static charge is given by-

$$E = 10^{-3} \frac{CV^2}{2}$$

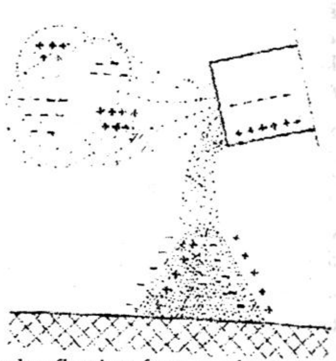
Where E = energy, microjoules, C = capacity of object, picofarads and V = potential, kilowatts. Mixtures of flammable vapours in air require 0.1 to 1 microjoule, flammable dust clouds require 5 microjoules upward and sensitive explosives less than 0.1 microjoule energy to cause ignition.

Charge accumulation must be avoided by detection by field meters (Static volt meters or a capacitance bridge) and various methods of electrostatic charge elimination (hazard control), as stated below. .

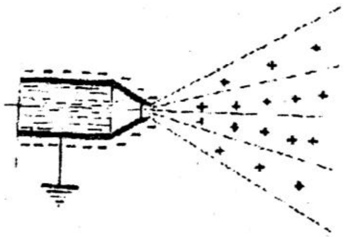
See figure 11.5 for examples of generation of static electricity (charges).



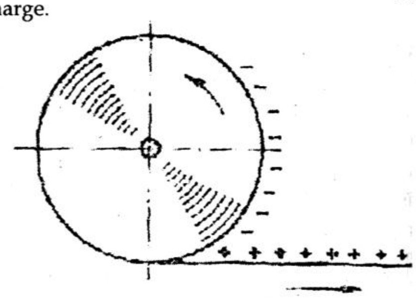
Insulating soles generate charge while walking on carpet.



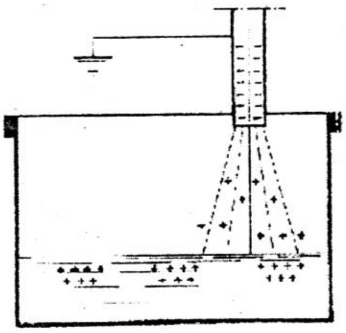
Powder flowing from a plastic bag generates charge.



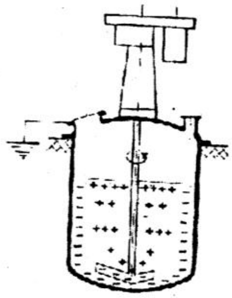
Lequid through matel nozzle generates charge.



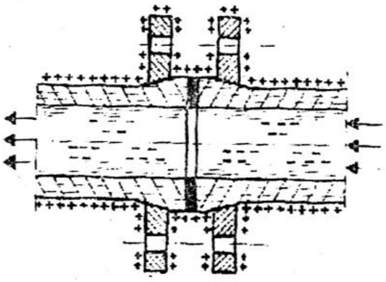
Unwounding plastic or paper film and the roll are charged.



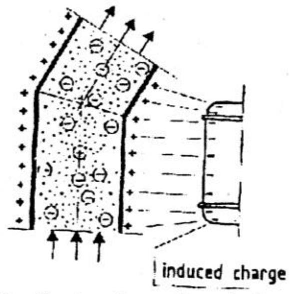
Non conducting solvent flowing through matel pipe generates charge.



Stirring of non conducting liquid in a vessel generates charge.



Non conductive liquid or powder flowing through glass or plastic pipe generates charge.



Powder flowing through a plastic pipe generates charge.

Fig. 11.5 Examples of generation of static electricity (charges).

9.2 Operations and Machines Generating Static Charge

Some examples are as under -

(A) Operations generating static charge

1. Walking on dry floors.

2. Touching and rubbing hand on, plastic hand rails.
3. Flow through long pipe lines of small diameter. Increase in diameter reduces static charge as friction reduces of the same flow.
4. Flow through filters, valves etc.
5. Stirring of liquid at bottom.
6. Splash filling of liquids or high velocity flow. Flow of liquid into tank.
7. Two phase (liquid & solid, liquid & gas or air, gas and solid) flows.
8. Loose floating objects.
9. Flow of air, steam (wet) or gas through opening of hose or pipe.
10. Directing air flow on or near electronic equipment e.g. compressed air cleaning of dust.
11. Putting or moving synthetic material on or near electronic equipment.
12. Putting on and off with jerk synthetic shirt from the human body.
13. Combing of hair
14. Process of mixing or agitation.
15. Rapid flow of powder, palettes, tablets etc. through chutes or pipe.

(B) Machines generating static charge -

1. Rollers or roller contact of dissimilar surfaces or moving belt or conveyor on it e.g. rubber mill, paper mill, calendar machine, dryer rolls etc.
2. Running of non conductive flat belts on pulleys or rolls.
3. Pulverizing machine where pulverized material passes on surfaces.
4. Long conveyor belts moving on support rollers.
5. Feed hoppers, silos and pneumatic conveyor where material slides on surfaces.

9.3 Hazards and Controls :

Static electricity is frequently generated but mostly it is not hazardous because it is too weak or leaks off as fast as it is generated. For its fast leaking or bypassing, good conductor (antistatic device) is required to connect the charged surfaces with the earth.

9.3.1 Hazards of Static Electricity :

As rubber is bad conductor (good insulator) of electricity, it accumulates static electricity to a high degree. Fires in rubber industry are mostly due to discharge of such heavy static charges.

If equipment is not grounded, static charge will continue to accumulate on it till it will discharge as a spark. Therefore grounding by a steel plate, copper wire or bronze brush is necessary.

Lightening from the sky is nothing but a discharge to the earth of enormous static charges generated and accumulated between the layers of air and clouds in the atmosphere.

Some specific hazards are as under

1. Shock if spark is not generated and the charged surface (not grounded) is touched by human body.
2. Fire or explosion if spark is generated due to discharge of static charge into flammable atmosphere.
3. Readings are distorted or changed in sensitive instruments.
4. Dust deposition on charged surfaces.
5. Clogging or obstruction to free flow of powders in chutes, silos or hoppers.

9.3.2 Control of Static Electricity :

Sequence to combat static electricity includes following steps

1. Prevent charge generation.
2. If this is not possible, prevent its accumulation.
3. If this is also not possible, prevent discharge from being hazardous, and
4. Prevent formation of flammable atmosphere near possibility of static electricity.

Mostly step-l is not possible but step-2 can be implemented effectively by ensuring earthing and bonding. For step-3, diameter of pipe/hole is increased, flow rate is decreased etc.

When two unlike materials separate quickly, static charge is generated at the point of separation. Ground wire should be attached where static charge is likely to occur. For proper ground connection, spring type or screw type clamp is used. Ground clamps are made of materials like stainless steel or beryllium copper alloy because they are good conductors of electricity and also non-sparking. Clamps should have sharp points and enough pressure to hold it firmly.

Coating of paint, rust, corrosion, grease, oil, resin etc should be removed at a point where ground connection is to be made. Thus grounding surfaces should be made clean if they are not.

Loose connection, broken clamp, broken wires and unclean metal surfaces should be checked before starting the work. Ground wire must be attached last after making sure that all connections are made properly.

It is important to note that it is more advisable and simpler to avoid having a flammable atmosphere than to try 'for charge avoidance. For this purpose inert gas filling is first required. Some specific control measures are as under:

1. Earthing (grounding) and bonding of equipment, pipe joints, flanges and parts.
2. Increasing the conductance of floors, footwear, wheels and tyres for personnel and moving equipment.
3. Increasing the conductivity of non-conductors by conductive additives, surface layers, films and humidification of the atmosphere.
4. Increasing the conductivity of the atmosphere by ionisation.
5. Using antistatic and conductive materials and static eliminators.
6. Earthing of moving machinery.
7. Use of antistatic belts or antistatic dressing to non-conductive belts at regular intervals.
8. All tanks, vessels, pipelines containing solvents or flammable liquids or gases should be separately earthed. Bonding of pipe lines at flange joints necessary unless metallic contact (continuity) is in between the flanges. Thus bonding is not required for wholly metallic connections having resistance to earth less than 10 ohm. However, bonding is necessary if non metallic (e.g. plastic, rubber, asbestos) components are there in between the joint.
9. Tank wagons and road tankers should be earthed while loading or unloading with flammable liquid or gas. Rail-track should be earthed and jumpers to be provided to connect rail to rail.
10. While pumping flammable liquids in tanks, the inlet pipe should extend and discharge at the bottom of the tank. A long feed (inlet) pipe or inner limpet for this purpose is desirable. At this time it is advisable to maintain an inert gas blanketing. Flow velocity should be restricted.
11. The pipe and nozzle of steam or water should be bonded while tank cleaning or steaming.
12. Liquid spillage and dust deposits should be removed as early as possible.
13. Good ventilation and good housekeeping are necessary to prevent flammable concentration.
14. Non-conducting plastic containers should be avoided to fill flammable liquids with flash points below 30°C.
15. Antistatic additives should be used to reduce the high resistance of liquids.
16. Keep all synthetic material at least 6 inches away from charged surfaces or electronic equipment.

17. While repairing or handling PCB or electronic equipment, use antistatic foam, antistatic grounded wrist strap and antistatic floor mat.
18. Reduce pump or flow speed while beginning tank filling, .transferring light material on the surface of heavy material of low conductivity, using water or air for cleaning purpose, while transferring a product of two phases such as immiscible liquids etc.

The most relevant IS 7689 on control of undesirable static electricity should be referred for 44 topics given therein. They include definitions, electrostatic charge, their physiological effects, discharges, electrostatics in liquids, powders, solids and gases, effect on personnel, earthing and bonding, use of tanks - metallic & non-metallic, road/rail tanker, small containers, transfer of liquids, pipelines, release of gases, spraying of paints and powders, handling of electro-explosive devices, earthing of personnel and hazards from clothing.

For earthing and bonding maximum earth resistance recommended is 10 ohm. Antistatic or conductive type materials can be used to avoid the retention of static electricity. Earth resistance for static charge dissipation should be regularly checked.

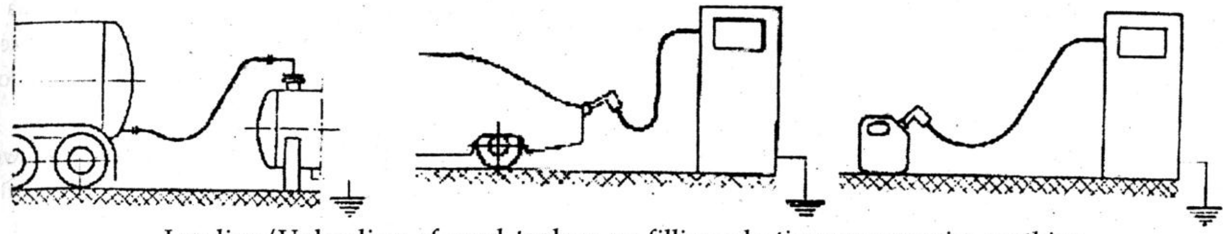
See fig 11.6 for control measures for static electricity.

10 ENERGY CONSERVATION AND SAFETY

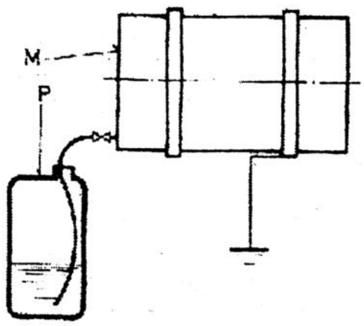
Energy conservation, particularly of electricity and heat, is itself a wide subject and has wide applicability throughout the world. It does not only improve efficiency and economy, but also improves safety and productivity. Thus its benefits are manifold.

See Part 3.1 of Chapter 2 for definition of accident, where it is also defined - in terms of energy loss. Physiological energy loss or energy loss from material, process or unwanted transfer of energy beyond the threshold limit is also called accident. Therefore from safety point of view energy loss should be prevented or minimised.

Energy and safety has direct relationship. High energy may cause more damage in case of accident.

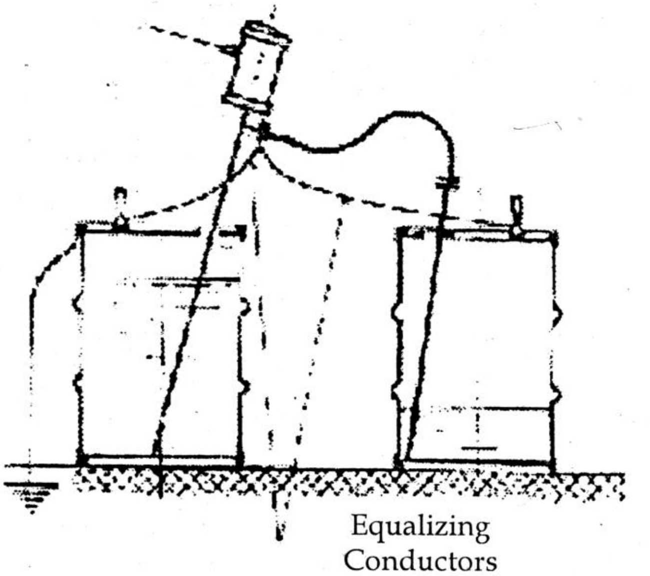


Loading/Unloading of road tankers or filling plastic canes require earthing.

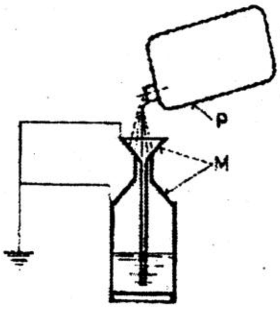


P : insulating plastic material M : Metal

Matel barrel requires earthing.

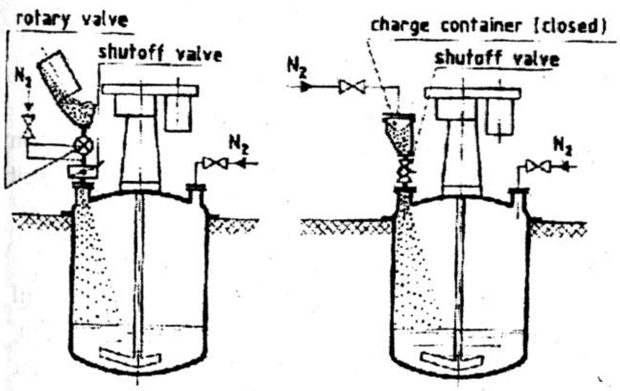


Drum pump and drums require earthing.

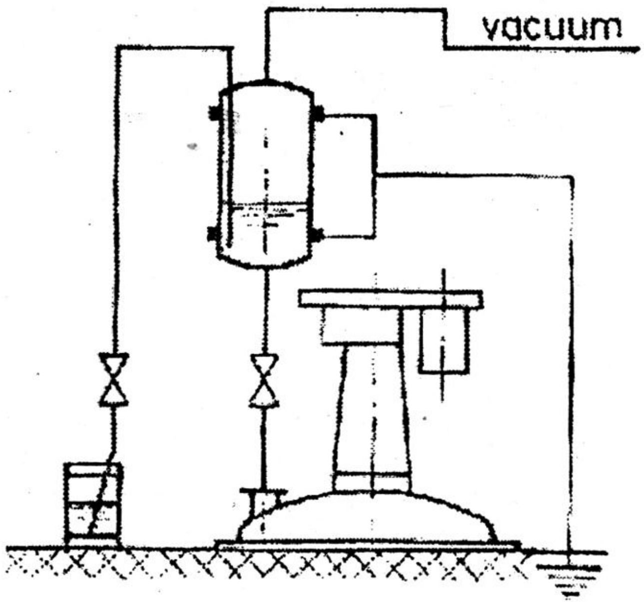


P : insulating plastic material M : Metal

Conductive containers, funnels and nozzles should be earthed and bonded.



Closed charging of solids into an inerted vassel requires earthing (two possible alternatives)



Filling pipe should be extended up to the bottom of the vessel. Measuring vessel and reactor both should be earthed.

Bulk storage of chemicals, operating at high pressure, temperature, flow, speed etc., high frequency radiation, high level of noise and vibration, high voltage power transmission, heavy friction, acceleration or kinetic energy... all are sources of great danger. They demand high cost of expenditure, consume more material and energy, make more pollution and always pose high risks in all directions.

Therefore it is in the interest of safety, health and environment to run the plant at minimum required level of inputs of energy, storage of materials, process parameters, speeds of machines and generation of chemical exposure, noise, vibration, radiation (including heat, light etc.), pollution, test conditions and so many areas of energy utilisation. An effective energy conservation programme should be worked out by technical experts and consultants, should be implemented at all levels and monitored continuously for expected results.

India has 16% of the world population but less than 1% of the world energy resources. More than 50% of the oil is imported. With large foreign debt, the rupee will be always weak and import of any form of energy like Coal, Oil or Gas will be a difficult proposition. Hence efficient use of all forms of energy is very important. For electricity, it is of particular importance as 70% of the power generation is thermal. Efficiency of thermal generation is 35%. With T & D losses of 20 to 25%, saving of I unit of electricity at user's end, leads to saving of 4 units of primary fuel.

In developed countries, industries have improved energy efficiency by 30 % .to 40%. Energy efficiency improvements have been gained by all types of industries like steel, chemical, cement, paper, engineering, textile, food etc.

In Gujarat and Maharashtra the Electricity Costs for industries is about Rs. 4.00 per unit (KWH). It may reach Rs. 5.00 in few years. Energy costs and profits are of the same order of magnitude in many industries. Reduction in energy costs can lead to significant improvement in profit. Some Indian industries have also achieved significant energy savings by systematic efforts. Proper selection of the equipment with better efficiencies, which are available in the market and proper design of the associated systems for operating at optimum efficiency are very important for obtaining energy economy. After the plant is stabilised and all major parameters are known, a second look at the system design may be rewarded with lot of savings at low cost.

For an effective energy saving program, a well trained team of plant personnel is the first and foremost requirement. You too can achieve Large Energy Savings by exposing your managers and engineers to the ideas and methods of improving energy efficiency.

An electrical energy conservation training programme may include following .or similar subjects:

1. Systems Approach to Efficient Use of Electricity.
2. Energy Accounting, Monitoring & Control.
3. Methods for Energy Efficiency Improvement.
4. Electric Motors/Starters/Efficiency Testing Methods.
5. Pumps & Fans.
6. Variable Speed Drives.
7. Electric Heating/Melting.
8. Thermal Insulation.
9. Electrolytic Processes.
10. Illumination.
11. Compressed Air.
12. Refrigeration.

13. Cooling Towers.
14. Maximum Demand/Power Factor Control.
15. Transformers & Cable Losses.
16. Cogeneration.
17. Management of Energy Conservation.
18. Information on Suppliers.
19. Case Studies.

As a result effective measures should come out as minimum energy inputs, savings of electricity, heat, steam, water, air etc. and optimum use of controlled energy.

See Energy Conservation Act. 2001 and Rules 2005 for more information. Guidelines from Mines and Energy Department are available. At every three years Energy Audit Report is to be submitted. Energy Manager is also to be appointed.

Industries should try to get the National Energy Conservation Award.

EXERCISE

1. Explain, State, Mention or Discuss :

1. The statement 'Electricity is a friend of men but it can become an enemy too'.
2. The safety provisions under the Electricity Act 2003 or those under Electricity Rules 2005.
3. What are the points insisted upon by the National Electric code ? OR State seven parts contained by it.
4. What do you mean by physiology of electric shock ? State main causes of electric shock on human body.
5. The effect of electric current or voltage on human body.
6. The effect of mains voltage (230 V) on dry and wet skin by an example.
7. What are the general precautions for safety in electric work ?
8. Major safety measures for electric work.
9. What are power cutting devices ? Explain safety requirements in their design and use.
10. Types of protection for electrical safety.
11. What do you mean by protective earthing ? Explain the part to be earthed and methods of earthing.
12. What is the meaning of 'no load condition?' What are the hazards of low (insufficient) current ? What are the safety measures for this?
13. Why ELCB is called an electric shock guard ? Explain its working.
14. Why earth, insulation and continuity tests are necessary ? Explain the reasons.
15. The meaning and types of earthing. Mention the standards of earthing.
16. What are current surges ? When do they occur? What are the protections against them?
17. Neutral connection system and safety aspect of it.
18. What do you mean by lightening arrestor'? Explain its arrangement and working.
19. The safety aspects of portable electrical apparatus.
20. Indian Standard and its classification of hazardous areas for electric work.
21. Type of flameproof electrical equipment necessary for three classes of hazardous
22. List different types of flameproof equipment and explain the utility of any five of them.
23. The phenomenon of static electricity and types of static charging.
24. Where bonding is not necessary to protect from static electricity ?
25. Various operations and machines generating static electricity.

2. Write Short Notes:

1. Type of electrical hazards.
2. National Electric Code.
3. Electric shock.
4. Personal sensitivity to electric shock.
5. Factors affecting severity of electric shock on man and woman.
6. Effect of electric shock on heart and other body parts.
7. Electric burns.
8. Threshold shock voltages at 50 c/s.
9. Effect of increasing voltages on body resistance.
10. Lock-out & Tag out.
11. Methods of protection for electrical conductors and connections.
12. Overload and short circuit protection .
13. Thermal protection.
14. Good earthing or Double protection.
15. Earthing for machine tools.
16. ELCB.
17. Earthing standards.
18. Earthing of portable power tools.
19. Voltage fluctuation and protective devices for it.
20. Hazards of borrowed natural.
21. Hazard and safety aspect of portable transformers.
22. Hazard area classification and its usefulness.
23. Safety measures for low and high risk areas of electric work.
24. Hazards of static electricity.
25. Control measures for static electricity.
26. Operations generating static electricity and specific control measure for their operation.

Reference and Recommended Reading

1. Indian Standards mentioned in this Chapter.
2. Electricity Act 1910 and Rules 1956.
3. Industrial Hazards and Safety Handbook, King and Magid, Butterworth.
4. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
5. Fundamentals of Electrical Safety, V. Manoilov, Mir Publishers, Moscow.
6. Electrical Safety Engineering, W. Fordham Cooper, Butterworth.
7. Electrical Safety, Swan H. E. , McDonald & Co., London.
8. Electrical Earthing and Accidents Prevention, M.G. Say, George Newnes Ltd., London.
9. Electrical Instruments in Hazardous Locations, Earnest C. Magison, Honeywell Inc., USA.
10. Industrial Wiring, Polyakov & Kovarsky, Progress Publishers, Moscow.
11. Accident Prevention Manual for Industrial Operations, NSC, USA.
12. National Electric Code and relevant Indian Standards.
13. Standard Handbook, for Electrical Engineers.
14. Protection of Workers from Power Frequency Electric and Magnetic Fields: A Practical Guide by ILO

15. Lockout/Tagout - A Practical Approach by Stephen M. Kelley

16. NIOSH Manual for Measuring Occupational Electric and Magnetic Field Exposures by Joseph D. Bowman, Michael A. Kelsh and Willam T. Kaune.

CHAPTER – 12

Noise and Vibration

THEME

Part A : NOISE

1. GENERATION, PERCEPTION, NATURE AND TYPES OF NOISE

Speech or communication is an essential need of human life and that is not possible without voice or sound.' Complete deafness takes away the charm of life. Poor hearing in old age creates problems. Poor listening induces loud speaking or shouting. Thus good listening or hearing capacity is -very much required throughout the life. Vibrations of air particles cause sound and make the communication possible.

But everything in excess is always harmful. vfr loZ= otZ;sr~ Unbearable sounder noise creates difficulty in communication and causes mental and physical stress resulting in illness and accidents.

Sound is a useful communication or pleasant sounds viz music, speech, while noise is a discord or unpleasant sound.

Centuries ago, in 1700, Ramazzini described deafness and hard hearing of workers who were hammering copper.

No more people were exposed to high noise before the Industrial Revolution. With the advent of steam power, attention was attracted towards noise as a hazard. Workers engaged in fabricating steam boilers were found to develop hearing loss which was termed as boilermakers' disease. Day by day mechanized industries increased with the effects of intense, mixed and complex noise levels at work places. General outside environment also became noisy.

The modern life of many types of industrial noise, high volumes of musical sound, noise due to vehicles and transports and addition of constant noise in environment front variety of sources have generated a Noise Problem. Throughout the world noise (unwanted sound) is considered as an environmental pollutant and statutory provisions are made to control it.

1.1 Generation of Sound / Noise:

Sound is an acoustic vibration generated due to movement of particles of an elastic medium (e.g. air, liquid, metal). Sound produces an auditory sensation between 16 Hz to 20000 Hz frequency range.

Physicians define noise as a superposition of sounds of different frequencies and intensities without any phase correlation. Physiologists consider noise as any unpleasant or disturbing sound.

Environmental noise is a noise of measurable intensity such as is normally noticed in workplaces.

Sound wave is generated when any object vibrates in air (or other medium) and the disturbed air particles spread away from the object in the form of a wave. See Fig. 12.1.

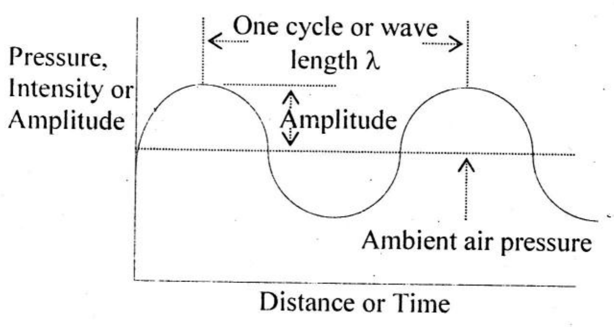


Fig. 12.1 Sound Wave

These waves in turn impinge on our ear drum and set it in vibration. Moving fluid and thousands of hair cells inside the car convert the vibrations into nerve impulses which are carried to the brain where the impulses are converted (interpreted) into what we hear as sound.

Mode of Sound Propagation:

Sound propagation in air is like ripples in silent water. Ripples spread out in all directions uniformly, ' decreasing in amplitude as they move away from the source.

For sound in air when the distance doubles the amplitude drops by half, thus following the inverse square law.

Thus if you are at a distance of 1 mt away from source of sound and move 1 mt further away from die source, the sound pressure level {SPL) will drop by 6 dB. If you move to 4 mt, it will drop by 12 dB, to 8 mt, drop by 18 dB and so on. This is true only when there are no reflecting or blocking objects in the sound path. Such ideal conditions are called Free Field Conditions.

With obstacles in the path of sound, part of sound will be reflected, part absorbed and remainder will be transmitted through the objects. How much sound will be reflected, absorbed or transmitted depends upon the properties of the object, its size and wave length of the sound. See Fie. 12.2.

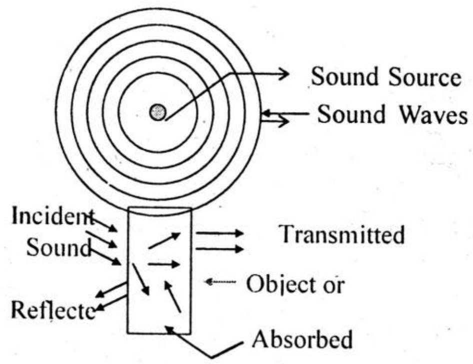


Fig. 12.2 Propagation of sound

In general, the object must be larger than one wave length in order to significantly disturb the sound. For example, at 10 KHz the wave length is 3.4 cms, even a small object will disturb the field, sound absorption and insulation are readily achieved. But at 100 Hz sound frequency the wave length is 3.4 mt and sound insulation becomes much more difficult.

1.2 Perception of Sound/Noise :

It is the human ear which perceives or hears the sound and sends the message to the brain through senses.

The human car is shown below in Fig. 12.3

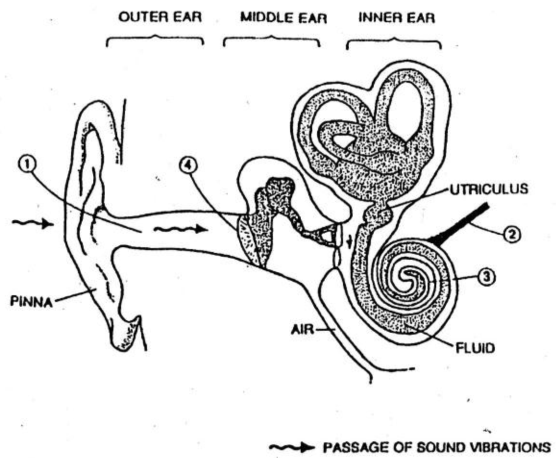


Fig 12.3 Human Ear

The ear has 3 parts - outer ear, middle ear and inner ear. The outer ear contains the external auditory canal which carries sound waves to the eardrum (tympanic membrane). The middle ear has eardrum and hammer which vibrate due to sound waves. This assembly transmits sound waves to the-inner ear after amplifying or diminishing the sound to protect the inner ear, thus regulating the sound level. Two muscle tighten the eardrum and give acoustic reflex as per brain's command. Due to high noise or many years o) hearing, these muscles weaken resulting in hearing loss.

The inner ear is a complex system of bony fluid-filled crevices and is responsible for our sense It sends message to the brain.

1.3 Nature and Characteristics of Noise

Noise is a sound but it is unwanted o undesired sound i.e. a sound without agreeable musical quality. It is an annoyance and interfere with work efficiency and causes accidents, hearing loss or deafness depending upon its type and period of exposure. Glorying and Wheeler's study show that the greater the length of exposure, the is the degree of hearing loss, especially in 4000 to 8000 c/s frequency.

Sudden and loud noise produces high reactions in all persons and loud and persistent noise (of high pitch) may produce deafness. Such noise should be eliminated if possible, otherwise, avoided by ear-protection.

The sound wave has following characteristics and relationships:

Frequency:

It is the number of pressure variations (vibrations) above and below atmospheric pressure (760 mm of Hg) i.e. the rate at which complete cycles of high and low pressure regions are produced by sound sources. Its unit is cycles/sec or Hertz (Hz). Normally human ear registers frequencies from 2020000 Hz. This is known as the audible range of frequencies. Frequencies below 20 Hz are called infrasonic and above 20000 called ultrasonic. Ear is most sensitive between 1000 to 4000 Hz and damage occurs above 4000 Hz. The instrument used to measure sound frequency is known as octave band analyser.

Wave length:

The distance required to complete one cycle of pressure is called one wavelength (X) or a distance between two crests or troughs of the wave

$$\text{Wavelength (h)} = \frac{\text{Speed of sound (S)}}{\text{Frequency (F)}}$$

where speed of sound = 344 m/s or 1130 ft/sec.

Period:

It is the time required to complete one pressure cycle and is reciprocal of frequency. It is measured in seconds (T).

Sound Intensity (1) or Amplitude:

It determines the loudness (though both are not same) and measured in terms of decibels (dB). At a specific location, the sound intensity is the average rate at which sound energy is transmitted through a unit area normal to the direction of sound propagation.

Intensity is the pressure or energy that the shunted air particles deliver to an ear. It falls off with distance and is given by the decibel or dB which tells us how many times bigger the intensity of a particular sound is than the intensity of the reference sound at the bottom of the scale. 'dBA' refers to sound level in decibels as measured on a sound level meter operating on a - weighing network (reference) with slow meter response.

Loudncss is the sensation produced in the human ear. It depends on the frequency and intensity of sound. Loudness levels in 'phons' of some industrial operations are given below (IS:3483) : In table 12.1

Table 12.1 : Loudness level of industrial operations

Industrial operation	Loudness in phons
Textile mills	90 to 110
Sugar mills (crushing)	105 to 110
Steel rolling	95 to 105
Drop forge hammer	130 to 145
Steel bar shearing	110 to 125
Riveting (steel plates)	105 to 110
Circular saw (wood)	100 to 110
Wood planning	115 to 120

Phons units of loudness are expressed on a logarithmic scale, while, **sones** units are expressed on a linear scale. Loudness level varies with different individuals and also with the two ears of the same individual.

Sound is usually measured in groups of frequencies. A convenient grouping is f_0,-$2f_0$, $2f_0$-$4f_0$,$4f_0$-$8f_n$ etc. These are called octave bands.

A sound with a rating of 2 sones is considered to be twice as loud as one of I sone.

Frequency is related to pitch and intensity is related to the loudness of the sound. Pitch refers to the quality of sensation of sound whereas loudness refers to the quantity of sound. Higher the loudness, higher is the intensity. Higher the pitch, greater is the potential to cause annoyance.

The audible range of young and healthy person is

0 dB (0.00002 N/m^2 or 20 uPa) - Threshold of hearing
130 dB (20 N/m' or 10-12 watts Threshold of pain

The dB scale is logarithmic and instrument used to measure sound intensity is called precision sound level meter.

Sound Pressure:

It refers to the root mean square value of pressure changes below and above the atm. pressure. Units are microbar or dyne/ cm^2, N/m^2 or Pascal. 1 µbar = 1 dyne/cm^2 = 0.1 N/m^2 = 0.1 Pascal.

See Fig. 12.4 for relationship between dB and Sound Pressure levels.

Sound Power:

It is the sound energy produced per unit time. Power is expressed in watts (W).

Sound intensity is also defined as sound power per unit area i.e. 1 =W/a.

See Fig. 12.5 for relationship between dB and Sound Power levels.

Inverse Square Law:

Sound travels in all directions from source and sound power is given by

$W = I \times a = I \times 4pr^2$

where a is the area of sphere surrounding source over which intensity is averaged. Hence

$I \alpha l/r^2$

Thus intensity is inversely proportional to the distance (radius r)

The louder the noise and the higher its frequency, the more damaging it can be.

Levels of some common sounds:

The sound levels (pressure) in both the units are given in Table 12.2

Table 12.2 Some Common Sound Levels:

Sound Source	Sound Pressure	
	dB	N/m^2 (Pascal)
Threshold of excellent hearing	0	0.00002
Threshold of good hearing	10	
Whisper	20	0.0002
Recording studio	30	
Average residence	40	0.002
Private office	50	
Conversational speech	60	0.02
Noisy office	80	0.2
Factory	90	
Passing truck	100	2.0
Punch press	110	
Riveter, chipper	120	20.0
Pipe organ	130	
Threshold of pain	140	200.0
Turbo jet	150	
Ram jet	160	2000.0
Saturn rocket	194	100000 (1 bar)

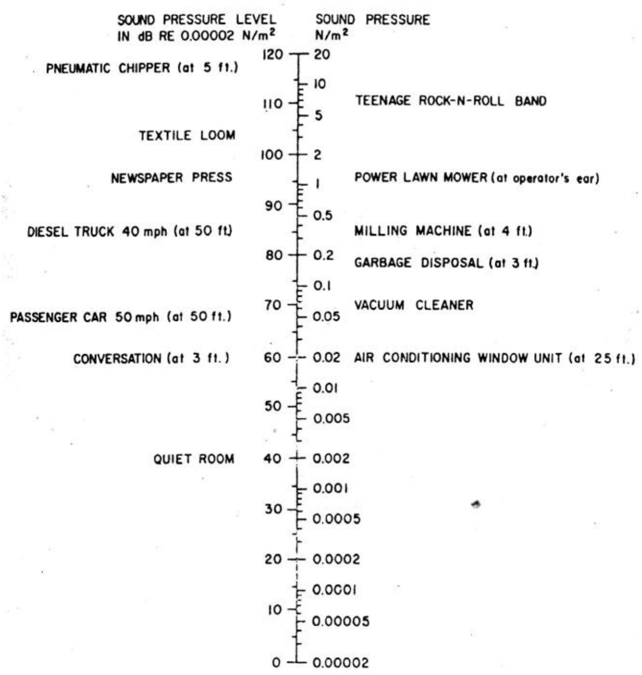


Fig. 12.4 Relationship between A-weighted Sound-Pressure Level in Decibels (dB) and Sound Pressure in N/M^2.

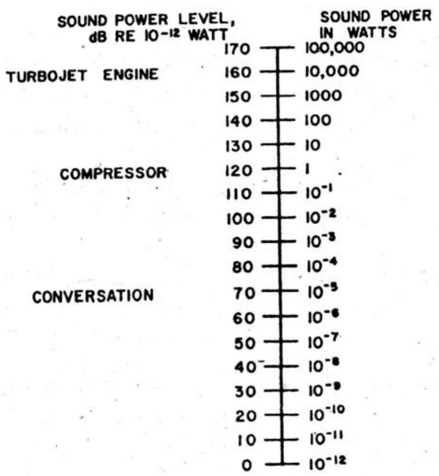


Fig. 12.5 Relationship between Sound Power Level in Decibels (dB) and Sound Power in Watts.

1.4 Types of Sound / Noise :

Sound or Noise is continuous when the source is constantly vibrating, e.g. motorised bell. It may be impulsive when the source causes vibration only for a short time e.g. sound from a drop forge hammer, explosion or a rifle shot.

Third category of sound is classified as fluctuating sound. In a large workshop where numbers of machines are in operation, noise level varies from time to time. As a result the noise pattern produced throughout the day is plotted. Then equivalent continuous level should be measured as a mean of fluctuating level.

2 EFFECTS AND HAZARDS OF NOISE

Moderate sound (F < 4000 Hz) is good but high sound or noise is hazardous.

The harmful effects of noise depend upon a number of factors:

1. Noise frequency and intensity.
2. Total length of exposure.
3. Length of exposure at a time.
4. Distance from the noise source.
5. Whether noise is continuous, interrupted, sudden or impulsive.
6 Whether ear protector is worn or not and
7. Individual susceptibility depending on age, health etc.

Excessive noise harms overall health and may contribute to -

1. Mental stress
2. Physical stress
3. Certain illness
4. Hearing Loss or deafness
5. Accidents and
6. Labour productivity.

Labour productivity is declined when workers are exposed to high noise level.
The harmful effects of excessive noise have been well recognised and it has been shown that such noise produces physiological and psychological effects on industrial workers, such as hearing loss, deafness, fatigue, irritation, annoyance, distraction, masking. Such effects are due to sound intensity.

J.L. McCartney's report 'Noise drives us crazy' shows that the work of assembling temperature regulators increased more than 37% and errors fell to one-eighth of their former number when the work was moved from the proximity of a boiler shop to a quiet area. Office work increased 8.8% and typists' errors fell 24% with a noise reduction of 14.5%. The noise reduction also decreased turnover or workers by 47% and absenteeism by 37.5%.

In factory where audible warning signals are to be heard or where an operator has to follow the operation of his machine by ear, the background noise should not be so loud as to mask (suppress) the signal or desired sound i.e. information sound to he heard.

Another noise criteria, known as Damage-Risk Criteria specify the maximum levels and duration of noise exposure that can be considered safe.

Whenever the noise intensity at the workers position exceeds the levels and duration suggested by the criterion curves, ear protection is recommended, since such exposure may cause permanent auditory damage.

Noise induced hearing loss is not ameliorated by the use of hearing aid. It may rather accentuate the frequency distortion.

Auditory ill-effects are of two types - temporary (threshold) hearing loss and permanent hearing loss including physical damage (ruptured eardrums). For details see Part 2.1.

Non-auditory ill effects are vibration or change in blood pressure or/and respiration or digestive system, dilatation of pupils and diseases like peripheral vascular disturbance IDH, vascular neuropathy, myopathy etc. Impulsive noise disrupts work performance. Continuous noise may have subtle psychological and psychomotor effects.

Speech or hearing interference (masking), annoyance, distraction, fatigue (mental and physical both), muscle tension, headache, nausea, tiredness, nervousness and contribution to other disorders are also reported. For details see Part 2.

If noise cannot be reduced at source, or its transmission to the environment cannot be prevented, use ear protection.

Exposure to excessive noise raises our hearing threshold i.e. the degree of loudness at which we first begin to hear.

Some health effects are discussed in details below:

2.1 Auditory Effects (Hearing Loss) :

These are serious health hazards resulting in hearing loss or deafness.

Hearing Loss:

Hearing ability can be greatly reduced by repeated or long exposure to high noise and this permanent effect is known as noise induced hearing loss.

It is impairment in ear that obstructs receipt of sound and understanding of speech in a sentence form (not in the form of test words). It is deafness. It is irreversible and incurable disease and can be corrected partly by hearing aids. Early audiometric examination can prevent further damage.

A young person with normal hearing can easily detects sounds in 6 to 20000 Hz frequency range. Important frequency range to understand speech is between 500 to 2000 Hz. Generally hearing losses in this frequency range which are compensable under Workmen's Compensation Laws.

Old definition of 'hearing impairment (loss)' means to begin to hear (threshold level) at 25 decibels more at 500, 1000 and 2000 Hz.

Ability to hear less than normal speech indicates degradation. It can result from ageing, long-term exposure to high noise (more than 90 dBA) or from a sudden, very high intensity noise (more than 160 dBA). Much of this degradation with age may be due to continuous exposure to environmental noise of modern society rather than to simple ageing. It is possible therefore that even where a factory complies with standards (say 90 dBA), workers will suffer hearing loss (due to exposure outside) and be eligible for benefits under Workmen's Compensation Laws. Therefore it is advisable to avoid loss claims, all attempts should be made to reduce noise to the lowest possible level and not to be higher than 80 dB.

One of the more extensive studies involving 400 men, 90 women and a period up to 40 years has been reported by LL Beranek and LN Miller, in 'The Anatomy of Noise', Machine Design, 14-9-1967. The group was regularly exposed to noise of 90 dB in each of the six octave frequency bands between 150 and 9600 Hz.

The study found that appreciable hearing losses at 3000, 4000 and 6000 Hz occurred in the first 15 years. At 500, 1000 and 2000 Hz, hearing losses increased less rapidly, as linear functions of exposure time. Some of the men tested, even at 30 years young, found it difficult to understand speech after about 10 years of exposure.

Men showed greater hearing loss than women because the women had regular work breaks during each shift while the men did not.

The ear's greatest sensitivity is in the 30005000 Hz range and hearing loss almost always occurs first at about 4000 Hz. With time and continued exposure, the loss extends to a range of 3000 to 6000 HZ. This diminishes hearer's ability to follow conversation. The most important frequencies for speech comprehension are at 500, 1000 and 2000 Hz. Therefore tests for hearing losses are made at these frequencies for compensability. The lowest level at which a person (under test) can detect sound is called hearing threshold. A loss is considered compensable if the degradation in hearing is 15 dB or more in speech frequencies. 'This means that the hearing threshold has been increased by at least that amount.

Effects of Chemicals on Hearing loss are also reported. Exposure to certain chemicals, along with noise, can also cause hearing loss. Toluene, lead, mercury, arsenic, CS, manganese, n-butyl alcohol, trichloroethylene, styrene are reported for such effect.

It is also reported that noise above 115 dBC (i.e. ceiling level) as 8-hour TWA and 155 dBC as peak exposure (impulsive or impact noise) to the abdomen of pregnant workers, beyond the fifth month of pregnancy may cause hearing loss in the fetus.

In such combined effect of noise and chemicals, periodic audiograms and their careful review are necessary.

A very loud impulsive noise can cause ringing in the ears (tinnitus) and immediate loss of hearing sensitivity. It can disappear if there is no further exposure to high noise levels. The impulsive or impact level should not exceed a ceiling limit of 140 dB (OSHA).

The ear can protect itself to some extent from noise by means of the reflex contraction of certain muscles in the middle ear which tries to limit the energy being transmitted inside. This protection is of little use when sudden very loud noise strikes the ear causing the muscle fatigue.

Factors affecting degree and extent of hearing loss are as under:

1. The intensity of the noise (sound pressure level).
2. The type of noise (frequency spectrum).
3. The period of exposure each day (duty cycle per day).
4. The total work duration (years of employment).
5. Individual's susceptibility.
6. Age and health of the worker.
7. Co-existing hearing loss and ear disease.
8. Character of the surroundings in which the noise is produced.
9. Distance from the source, and
10. Position of the ears with respect to sound waves and wearing ear protection or not.

The first four factors are called noise exposure factors and are more important.

Because of so many factors i.e. possible contributory causes and complex relationship of noise and exposure time to threshold shift (reduction in hearing level), time required to establish criteria t(protect workers against hearing loss may last many years.

The signs and symptoms of hearing loss are

1. Ringing in the ear at the end of the work shift slight headache, tiredness, dizziness.
2. Intermittent ringing in ears.
3. Normal hearing is affected - if background noise is present, incapability of picking up conversation, cannot hear ticking clock etc.
4. Feeling of hearing insufficiency is manifest.

Reduction in hearing capacity is not on) quantitative but also qualitative, that is, sounds a; perceived in an abnormal manner.

Diagnosis and special tests include audiometric examination and monitoring noise levels at the work place.

Hearing loss is of two types - temporary and permanent . They are also classified as conductive sensorineural and mixed hearing loss.

Temporary hearing loss can be caused by exposure to loud noise for up to a few hours, which numbs the hair cells. Fortunately, hearing is usually restored after a period away from noise.

Permanent hearing loss occurs when exposure to loud noise permanently damages or destroys the hair cells. Hearing cannot be restored. Signs of permanent hearing loss include -

1. Inability to hear pitched or soft sounds.
2. Trouble in understanding conversation, or speech heard over the telephone.
3. Ringing or roaring m the ears (tinnitus).

Any condition interfering with transmission of sound to the cochlea (inner ear part) is classified as conductive hearing loss'. It can be due to wax in auditory canal holes in eardrum, blockage of Eustachian tube, fluid in the middle ear secondary to infection. This type of loss is also due to medical or surgical treatment.

Sensorineural hearing loss is mostly irreversible. It involves the organ of corti and degeneration of the natural elements of the auditory nerve. It indicates sever injury to the hair cells. This type of loss occurs due to various causes including presbycusis, viruses (e.g. mumps), some congenital defects and drug toxicity (e.g. streptomycin).

Mixed hearing loss occurs when above both the types of losses are found in the same ear.

Central hearing loss means person's difficulty to interpret when he hears. The abnormality is localized in the brain between the auditory nuclei and the cortex.

Psychogenic hearing loss indicates nonorganic basis for threshold elevation. It may be due to malingering and hysteria.

No cure exists for hearing loss caused by noise. Hearing aids do not restore noise damaged hearing, although they help some people if such aids are properly selected.

Exposure to intense noise creates a temporary threshold shift (TSS) first. This is greatest from 1 to 24 hours after the exposure and reduces gradually if the noise has not been too loud. or has not been too long. This condition is also known as auditory fatigue. This effect is transitory i.e. removable. It is of two types TTS, and TTS,,. The later persists beyond 16 hours.

Repeated exposures produce a permanent threshold shift (PTS). If no recovery is noticed within a week (i.e. no hearing improvement by then), a return to the level before exposure is improbable. It is a noise induced hearing loss.

While deciding whether a certain noise is a hazard, the important factors are both the sound level and the number of hours of exposure per day. Table 12.4 and 12.5 given in Part 4 must be followed for that.

Hearing loss is a notifiable Disease under the Factories Act 1948 :

Noise induced hearing loss (exposure to high noise levels) is a notifiable disease under the Third Schedule of the Factories Act and duty is cast upon both the manager of the factory and the medical practitioner attending the person affected, to report to the Chief Inspector of Factories without delay (Sections 89 & 90).

2.2 Non-auditory Effects:

These are the effects other than the hearing loss and mostly temporary in nature. They may be disappeared if their causative factors are removed.

2.2.1 Speech or Hearing Interference and Masking :

Oral communication is interfered by a noisy environment and misunderstanding may be created about information being transmitted. It can lead to accidents. Such sound effect is called masking.

Masking is a level in decibels, by which a sound must be increased to be understood in the presence of another, interfering sound.

Tests were conducted of reception of pure tone (single frequencies) communications, where masking was also provided by pure tones. It was found that the intensity of the message to be communicated had to be increased 15 to 30 decibels to become understandable.

Various methods to measure the effects of noise levels on speech communications are based on relationships among noise levels, voice (speech) levels and distance between speaker and listener.

2.2.2 Annoyance :

Normally people are annoyed by noise. However types and levels differ from person to person. Rock music annoys people who like classical music and vice-versa. Acclimatisation or tolerance to certain level is an important factor. People who have been exposed to certain noises over a long period develop a tolerance to that level. The same noises may annoy other persons who have not developed the tolerance and to such a degree their efficiency is degraded. They may become more prone to errors or accidents.

Normally louder noise or unexpected impulsive -noise can be more annoying. High frequencies are more annoying than low frequencies.

2.2.3 Distraction :

It is another noise effect that diverts attention of a person. For example/passengers talking with a driver of a bus can distract his attention which may lead to an accident. Persons talking in the vicinity can distract the attention of other persons even if it does not annoy them. The sudden ringing of a telephone or any audio signal can distract attention and disturbs concentration.

2.2.4 Physiological Effects :

Sleep disturbance (WHO report, even at less than 35 dBA) and stress reaction (e.g. jet aircraft personnel exposed to 120 dBA or more) have been noticed.

Cancer: A case study was published in 'Current Science' weekly. 40 female rats were kept under the effect of 25 kHz ultrasound waves daily for one minute and for a period of six months. In 70% of these test-rates, cancer tumours were observed, skin wrinkles were seen and their hairs fell off. They were feeling difficulty in movement and died earlier than normal rates. Dr. S.N. Chatterji of Nuclear Physics in Saha Institute and Dr. Pratima Sur of Indian Institute of Chemical Biology carried out this experiment and warned against this ultrasound hazard mostly found in equipment used for biological and medical diagnosis. (News 10-8-98).

Adverse effects on work output, efficiency and morale are another non-auditory effects of noise. Fatigue and mental health' effect may also occur. However such effects are varying and many a times human adaptability nullifies such effects.

2.2.5 Behavioural Effects:

Adverse effects on work output, efficiency and morale are other non-auditory effects of noise. Fatigue and mental health effect may also occur. However, such effects are varying and many a times human adaptability nullifies such effects.

2.3 Impact Case Studies :

Systematic noise measurement in work environment, audiometric examination of workers to detect hearing loss, study of correlation of occupational noise and its impact on man or any research work on such noise impact studies are most desirable.

In 1956, Robinson and Dadson had tested a group of 51 people of average 20 years are. Additional data were obtained by Muson on 8 men and 2 women with the average age of 24. Conclusions of this study

1. A characteristic known as minimum audible field (MAP) is obtained when young people of good hearing ability are tested.

2. At low frequencies (Hertz) the sound pressure level (dB) must be high before a tone (hearing threshold) can be detected. At high frequencies noise is audible at low pressure (dB) level. At 16 Hertz frequently, first noise is audible at ' 80 dB while at 12500 Hz it is audible at 20 dB.

3. The initial discomfort threshold starts at 120 dB (between 250 Hz to 7500 Hz).

4. The initial pain threshold starts at 140 dB.

In 1961, Gloring determined that permanent deafness at a frequency of 4000 Hz from daily exposures of 5 to 8 hours reached a maximum at @12 years of exposure.

Many studies have revealed that high noise levels can be tolerated if exposure time is decreased sufficiently. Table 12.3 in Part 3.4 indicates this effect

Experiments in laboratories have shown that the presence of continuous loud noises disturb the attention and increase the frequency of momentary lapses in efficiency.

Dr. Jansen of West Germany conducted a study of the psychological effects of noise on steel workers. Over 1000 workers were interviewed and tested. A group of 2/3 workers who were working in noise level above 90 dBA was compared to a group of 1/3 workers who were working in less than 90 dBA noise. The average worker was 41 years old and had been on his job for II years. Workers of both the groups were matched as closely as possible according to their economic, social and ethnic backgrounds. The results of comparison revealed that –

1. Workers who worked in less than 90 dBA were easier to interview than those who worked in more than 90 dBA noise.

2. Workers exposed to more noise were found more aggressive, distrustful and in some cases, paranoiac. A contributory cause of hearing loss was also noted.

3. Workers exposed to higher noise had more than twice as many family problems. Thus noise 'affects a worker's behaviour not only on die job, but at home also.

In the middle of 1950, Dr. G Lehmann and his team studied the effects of noise on human body by carrying out various experiments and concluded that

1 Noise has effect (shrinking) on small blood vessels, especially pre-capillaries. It makes them narrower. This effect is known as vasoconstriction.
2 Noise causes reduction in blood supply to various parts of the body.
3 Noise decreases the stroke volume of the heart thereby decreasing blood circulation in the body.
4 87 dB noise for 3 seconds constricted arterioles in the fingers and cut down the volume of blood by one-half. After the noise stopped, it took @5 minutes for the arterioles to fully recover.

Earlier experiments had noted the adverse effect of high noise on blood vessels which feed the brain, headache due to persistent noise and heart attacks. Noise wears down the nervous system, breaks down our natural resistance to disease and power of recovery thus lowering the quality of general health.

Noise impact studies are essential to know the effect of high noise of present day machinery like air compressors, diesel generators, high speed power looms, POY spinning machines etc. An industrial hygienist should be employed for this.

3 MEASUREMENT AND EVALUATION

3.1 Sources of Industrial Noise :

Before studying methods of measurement, it is necessary to know the main sources of industrial noise. They are:

1. **Impact :** It is the most intense and wide spread of all industrial noises. Impact noise is usually impulsive but it can be continuous as in case of tumbling. Operations like forging, riveting, chipping, pressing, cutting, weaving, tumbling and sheared steel plates falling one over another produce such noise.

2. **Friction** : Friction processes like grinding, sawing, sanding, cutting and turning on lathes and other machine tools, brakes and less lubricated bearings produce noise.

3. **Reciprocation :** Vibrating, reciprocating 'or unbalanced rotating machinery radiate noise and vibration directly.

4. **Air Turbulence :** High velocity air, steam or gases cause noise. The intensity increases with the velocity of the air stream. Examples are exhaust noise from pneumatic tools and jet engines.

5. **Other Noises :** In addition, there are other noises also, such as humming noise from transformers and whining noise from turbines.

3.2 Need of Measurement:

Measurement of sound provides definite quantities which describe and rate sound. This measurement can be useful in

1. Improving building acoustics.
2. Permitting precise, scientific analysis of annoying sounds, and
3. Giving a clear picture on identification of damage to hearing and suggesting corrective measures to be taken. Hearing loss can be determined by measuring a person's hearing sensitivity by audiometry.

3.3 Methods of Measurement :

IS:3483 describes following points :

Intensity levels in the different octave bands are measured by a sound level meter in conjunction with octave-band filters.

The noises are picked up by a high quality microphone, passed through an octave-band filter and the sound pressure levels recorded on a level recorder. Alternatively, noises recorded on a magnetic tape or the recording system has a substantially uniform frequency response over the entire audio frequency range.

Impact noise, which are highly complex in nature are measured with an impact noise analyser and also simultaneously recorded on a magnetic tape recorder to facilitate octave-band analysis. It is also sometimes displayed on oscilloscope screen.

As the noise levels are not the same at all locations inside the factory or workshop, the levels are measured mostly at locations enveloped by high integrity noises. Also while determining damage risk, it is necessary to measure the noise levels as close to the operator's ear position as possible.

The methods to be adopted to measure and assess the degree of noise hazard depend on whether the objective to be attained is to assess -

1. The hearing loss (auditory effect).
2. The interference with communication essentials for safety and productivity (Non auditory effect), and
3. The hazard involve in the task (to study a specific problem).

Standard methods and instruments should be used for measurement and the results obtained should be compared with threshold limits. See Table 12.3 in Part 3.4. National or International standards should be followed. 85 dBA is an alert threshold limit and 90 dBA a hazard threshold limit. Ear protector is must to work in exposure exceeding 115 dBA. When noise levels are evaluated, normal working conditions and circumstances causing the highest noise levels must be considered.

For measuring steady-state or continuous noise, the equivalent continuous sound level should be determined in dBA and frequencies be analysed as per standard methods.

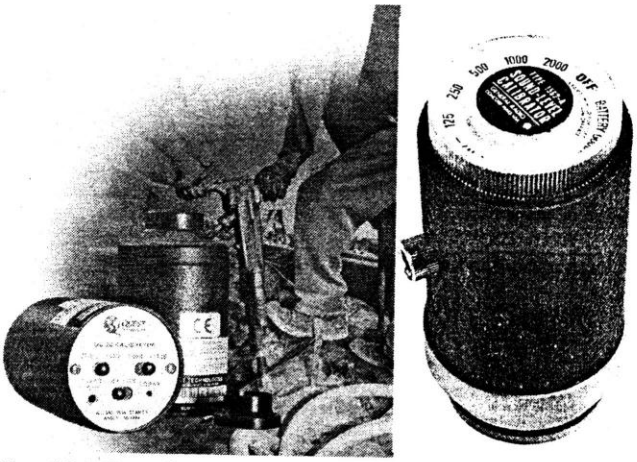


Fig. 12.6 Sound Level calibrator.

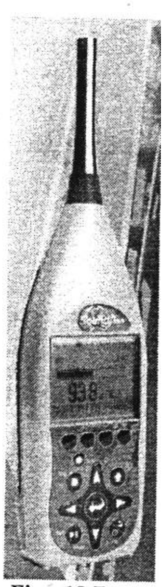


Fig. 12.7
Sound level

Impulsive or non-steady-state noise is I measured either by using sound level I meter in 'impulse' position and I calculating mean value of 8 hour per day, or by applying positive correction factor, generally 3 to 10 dB added to the slow response values, and then choosing the higher result.

Risk areas for measurement can be selected (1) Where noise hazard is liable to be present (2) Supervision, inspection or medical examination suggest that there may be a noise hazard and (3) Workers complain such inconvenience to them.

Where speech communication at normal voice is interfered at a distance of 50 cm, noise level should be assessed .

The noise levels should be measure) at a height of @ 1.5m above the work floor and at distance of at least 1 mt from the walls. It is advisable to establish the mean value of the sound level recorded in different directions.

Noise level should be measured at the worker' head level in his normal work posture or at a distance of I m from either side of his head position.

A noise chart should be prepared of the area where the measured noise levels are equal to or in excess of 80, 85, 90, 100 and 115 dBA. The Measurement Report:

A very important part of sound measurement is careful documentation of the measurements and result A good measurement report should contain at least the following information.

1. A sketch of the measurement site showing applicable dimensions (e.g. size of room machine dimensions), the location of the microphone and object being measured.
2. Standard(s) to which measurements are made.

3. Type and serial number of instrument (s) used.
4. Method of calibration.
5. Weighting networks and detector responses used.
6. Description of type of sound (e.g. impulsive continuous, tones etc.).
7. Background noise level.
8. Environmental conditions (e.g. type of sound field, atmospheric conditions).
9. Data on object being measured (e.g. machine type, load, speed etc.).
10. Date when measurements were performed.
11. Any other information.

With a carefully written report, future comparisons will be more accurate and reliable.

Noise Dose Measurement:

Fig. 12.8 Personal Noise Dose Meter

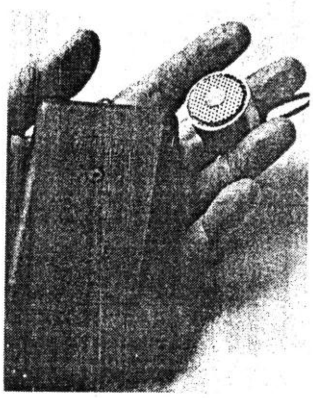


Fig. 12.9 Wearable noise monitor (battery-powered)

A noise dose is a measurement of noise or individuals who move between many different noise environments during the working day and can be obtained by using a noise dose meters.

Noise dose meter is a portable instrument which can be carried in a person's pocket. The microphone can be .operated from the noise dose meter body and should be mounted close to individual's more exposed ear.

Noise dose meters display the percentage of daily allowable noise dose. Personal noise dose meters are miniature integrate sound level meters. They directly measure the noise continuously and at the same time read out (display) noise does as a percentage of maximum allowable (100%) over an exposure period of 8 hrs. Beside this it also indicates when certain levels are exceeded i.e. 115 dB(A) maximum allowable and 140 dB(A) peak.

Discretely varying Noise Levels :

Many employees are exposed to a certain number of discretely varying noise levels usually because the noise is cyclical or varies stepwise at their work station or because the job requires them to move around the department or plant.

Noise codes describe procedures for summing a series of partial doses that such employees receive during their working period. Take a simple ISO example where an employee is exposed to 90 dB(A) for half of his working period and to 93 dB(A) for the remaining half. Since full working periods at 90 and 93 dB(A) represent doses of 100 and 200% respectively, half period doses are accordingly 50 and 100% giving a total dose of 150%.

In addition OSHA and many other national standards impose an overriding limit of 115 dB(A) "S" which should never be exceeded for any length of time.

One method of determining the noise dose of mobile employees is through the job-study interview. First/ a noise survey is conducted throughout the factory to determine the noise level at each working location. Then each employee is interviewed to determine what locations he works at and for how long. This rapidly leads to the determination of noise doses received by a large number of employees, furthermore periodic updates can be performed quickly. The job-study interview method readily lends itself to computerised record keeping. It is also a valuable aid for setting priorities in noise control schemes by identifying locations where the noise doses are excessive. A record form may be of the following type:

Employee noise exposure record

Employee name ______________________________

Date ____________________ Signed ____________________

Interview		Computation iso		
Work location	% time	Db (a)	8 hr dose	Partial dose *
A-5	60	85	30%	18%
A-8	5	95	315	16
B-21	10	88	60	6
D-13	25	91	125	31
	100			
			Total dose	71%

Recommendations :
Within ISO limits

$$\text{* Partial dose} = \frac{\text{\% Time}}{100} \times \text{8 hr dose}$$

3.4 Permissible Limits of Noise and Evaluation :

The recognition, evaluation and control of noise hazards include -

1. Setting objectives for a noise abatement programme.
2. Measurement of noise levels at workplaces and also with a moving man by measuring his doses of exposure.
3. Comparing the measured values with the permissible exposure limits and assessing the situation whether within limit or needs control measures (90 dBA under GFR).
4. Controlling exposure of excessive noise, and
5. Monitoring the hearing of exposed persons.

First three steps are 'evaluation' and the last two steps call for engineering control measures, audiometric and hearing conservation programmes.

First the company must decide the objectives to search for noise levels, to measure them by appropriate instruments and methods and by measuring levels at workers' ear levels, to set damage-risk criteria, to follow legal criteria and by comparing the measured levels with the desired (legal) levels to plan, design and implement the control measures.

The purpose of damage-risk criteria is to define maximum permissible noise levels in the hearing levels of exposed workers during their working life-time. Legal criteria should be accepted. See Tables 12.5 to 12.8 in Part 4.

As mentioned ACGIH booklet, TLVs for noise to prevent a hearing loss at higher frequencies such as 3000 Hz and 4000 Hz are given in Table 12.3.

Table 12.3 : TLV for Noise (ACGIH, 2007)

Duration per day (exposure time)		**Sound level dBA (TLV)**
24	Hours	80
16	Hours	82
8	Hours	85
4	Hours	8/8
2	Hours	91
1	Hours	94
30	Minutes	97
15	Minutes	100
7.5	Minutes	103
3.75	Minutes	106
1.88	Minutes	109
0.94	Minutes	112
28.12	Seconds	115
14.05	Seconds	118
7.03	Seconds	121
3.52	Seconds	124
1.76	Seconds	127
0.88	Seconds	130
0.44	Seconds	133
0.22	Seconds	136
0.11	Seconds	139

In measuring above values, standard sound level meter or dosimeter is to be used arid no exposure above 140 dB is permitted. The meter response should be kept slow. A dosimeter or integrating sound level meter should be used for sounds above 120 dB. Exposure is to be limited by noise source and not by administrative control. Method and formula to calculate the combined effect of two or more periods of noise exposures of different levels are also suggested.

The TLVs in Table 12.3 should be used as guide in the control of noise exposure and due to individual susceptibility. They should not be regarded as fine lines between the safe and dangerous limits. The TLV cannot protect all workers from the adverse effects of noise exposure. It can protect the median of the workers against slowly growing hearing loss.

It must be noted that a hearing conservation programme with audiometric testing is necessary when workers are exposed to noise at or above the TLV levels.

Hearing impairment should be evaluated in terms of a worker's ability or inability to hear speech under daily conditions. To hear sentences and to repeat them correctly indicates good hearing ability. Workers working in a noisy environment should be regularly checked for any detrimental effect on their hearing.

The critical factors to analyse noise exposures are 1. A weighted sound level.
2. Frequency composition or spectrum of the noise. 3. Duration and distribution of noise exposure during a typical workday.

Most of the industrial noise falls within 70 to 115 dBA. Below the lower level (70 dBA) it is safe and above the upper level (115 dBA) it is unsafe. In addition, type of noise and duration of exposure must also be considered. Hearing loss is directly related to total exposure time and the continuous exposure.

Table 12.4 shows the Acceptable Exposures in

dBA as a function of number of occur exposures per day.

°\ A variety of sound measuring insh'urntPP e>»-

A variety of sound measuring instruments are 1 available such as sound level meters, octave band! analysers, narrow band analysers, sound survey meters, tape and graphic level recorders, impact sound level meters and equipment for calibrating these instruments. Of these, the first two provide ample information.

A sound level meter is used to determine the noise exposure at the test time at a particular place. A noise dosimeter (to be worn by the worker) can be used to determine the exposure pattern of» particular individual. Octave band analyser is used to determine where the noise energy lies in the frequency spectrum.

Sound measurement falls into two main divisions, source measurement and ambient noise measurement. A source may be a single piece of noise or a combination of equipment or systems or even an entire plant. Ambient noise measurement ranges from studying a single sound level to making a detailed analysis showing hundreds of components of a complex vibration.

Thus by measuring high noise levels at work places and interrogating workers regarding hearing difficulty if any and carrying out noise surveys, noise values are evaluated and their effects are also determined by audiometric tests on workers. This suggests the necessary steps for noise control. For assessment of measured values and control measures, statutory provisions and IS are useful.

4 STATUTORY PROVISION

In the 3rd Schedule under the Factories A 'Noise induced hearing loss' (exposure to high noi levels) is included as a notifiable occupational disease

Schedule 23 u/r 102 of the Gujarat Factories Rules, defines high noise as 90 dBA or more and requires that -

1. No worker should be exposed to high noise level.

2. Ear protectors should be given to workers if engineering control to reduce noise is not possible and

3. Workers exposed to high noise should be auditory examined by a doctor within 14 days of his first employment and thereafter re-examined once in every year.

Schedule 24 u/r 114 of the Maharashtra Factories Rules 1963 and Schedule 28 u/r 95 of Tamil Nadu Factories Rules 1950 give table of permissible levels that are reproduced in Table 12.5 & 12.6 as under :

Table 12.5 : Permissible Exposure in case of Continuous Noise (also. OSHA standards)

Total time per day in hours	Sound level dBA
8	90
6	92
4	95
3	97
2	100
1.5	102
1.0	105
0.75	107
0.50	110
0.25	115

No exposure is permitted over 115 dBA.

Table 12.6 : Permissible Exposure of Impulsive / Impact Noise

Peak sound level in dB	Permitted number of impulses or impacts per day
140	100
135	315
130	1000
125	3160
120	10000

No exposure is permitted over 140 dB peak sound level.

Under Schedule VI Part E (u/r 3A) of the Environment (Protection) Rules, 1986, Noise Standards are prescribed as given in Table 12.7.

Table 12.7 : Noise Standards (after 1-4-2005)

A	Noise Limits for Automobiles, at the manufacturing stage	dBA
(a)	Two wheelers (80 cc to 175 cc)	75-80
(b)	Three wheelers	77-80
(c)	Passenger Vehicle (> 3.5 ton)	78-80
(d)	Good Vehicle (up to 3.5 ton)	76-77
(e)	Goods Vehicle (> 3.5 ton)	77-80
B	**Domestic appliances and Construction equipment at the manufacturing stage**	**dBA**
(a)	Window Air Conditioners 1-1.5 T	68
(b)	Air Coolers	60
(c)	Refrigerators	46
(d)	Compactors (rollers), Front loaders, Concrete mixers, Cranes (movable), Vibrators and Saws	75

Sch. Ill u/r 3 of the above rules prescribes noise levels in public areas as given in Table 12.8.

Table 12.8 : Noise Level in public areas (EP Rules)

See similar table in Part 10.13 of Chapter-28.

5 INDIAN STANDARDS

Noise: Some IS on Noise are : Noise reduction in industrial building 3483, assessment of noise exposure. during work for hearing conservation purposes 7194, ear protectors 6229, 8520, 9167, sound insulation of non-industrial buildings 1950, noise by electrical machinery 6098, noise by road vehicles 3098, 10399, noise by machines 4758, noise abatement in town planning 4954, airborne acoustical measurement 9876, airborne noise from compressor 11446, airborne noise from pneumatic tools and machines 11702, from gas turbine 10534, from machine tools 10988, assessment with respect to community response 9989, permissible limits from rotating electrical machine 12065, sound level meters for motor vehicles 3931, general purpose 3932, noise levels on onboard ships 13161.

Acoustics noise test 9000 (part 21), acoustical design of halls 2526, acoustics in buildings, glossary 9736, acoustics emission testing, terminology 12710, sound system equipment 9302 and sound system for conferences 11456.

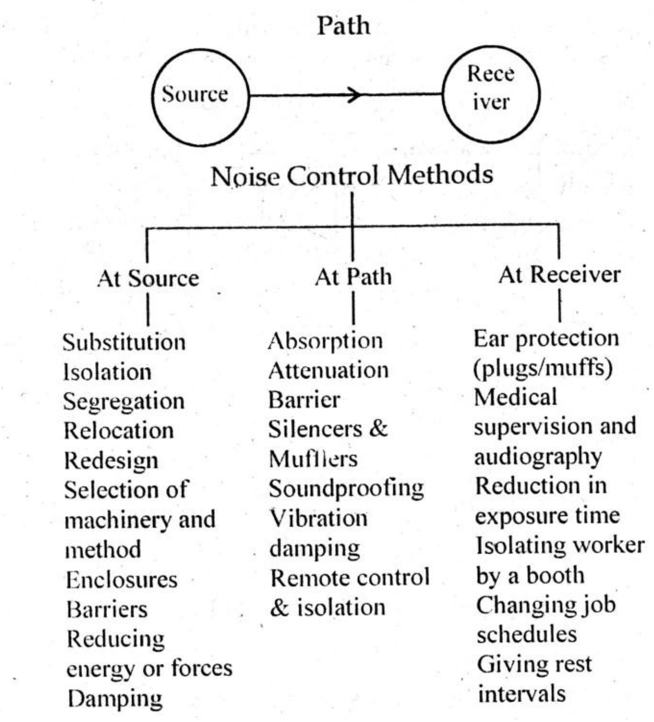
The first mentioned IS:3483 is very much useful to know-terminology, types of noise, frequency distribution, sources of noise, measurement of noise, methods of reducing noise and acoustical absorption devices.

6 CONTROL METHODS

First step is to measure the quantity and quality of noise by sound level meter, octave band analyser, sound dosimeter, audiometer or vibrometer. Control areas are the source, path and the receiver. Control methods should be aimed at

1. Controlling noise at sources.
2. Precluding the propagation, amplification and reverberation of noise, (path)
3. Isolating the workers (receiver).

Based on this, the control methods for prevention and reduction of noise can be classified as under:



6.1 Control at the Source :

Much noise can be eliminated by good engineering design. Wire mesh screens instead of sheet metal panels reduce vibrating noisy surfaces. Lining of absorbent materials would also reduce noise considerably. Machines can be mounted on rubber or other materials so that vibration and noise will be reduced. Quitter machine with plastic or rubber parts, lubrication, tuning and well maintenance give less noise.

Noise sources are of three types (1) Mechanical forces such as vibration of solid or liquid surface (2) Aerodynamic forces such as turbulence in air or gaseous environment and (3) Electrical forces such as electric arc or electric corona discharge.

Vibrations can be reduced by maintaining dynamic balance, diminishing the force causing vibration, reducing rpm, increasing duration of work cycle.

Response of vibrating elements can be reduced by increasing their damping power and improving fastening.

Liquid/gas flow rate should be reduced. Acoustic insulation on pipes can reduce 10 to 20 dBA.

Other measures include conversion of reciprocating movements into rotational movements, replacement of sudden stoppage by gradual braking, helical teeth instead of straight teeth on spur gears, prevention of impact of falling materials, installation of damping elements at points of contact between machine and plant elements, proper design of fan blades, proper tool and cutting speed in conformity with the material, proper design of air lines, ventilation ducts, gas mains and liquid pipes to prevent noise propagation, providing rubber tyres on trucks, trolleys etc., reduction in noise radiating surface area, machine guards of perforated sheet or wire mesh instead of plain sheet, reducing transmission of mechanical vibrations, inserting rubber or felt pads between the ends of the spring and the surfaces to which it is fastened, use of felt/cork as resilient mats or pads under machine bases, using isolators between the machine' and its foundation, heavy machines likely to cause impact noise should be rigidly mounted on massive concrete blocks having weights many times greater than the weights of the supported machines, loose and flexible connections in all pipes and conduits lending from vibrating machine, reduction in clamp sizes, use of sharp cutting edges, wobble dies in forging, quitter dies, use of anti vibrating mounts, mufflers for exhaust pipes and use of asphalt or tar for vibration damping.

Noisy machine may be placed in an enclosure or behind a barrier. A close-filling acoustic (insulated) box serves good purpose. The inside of the enclosure can be lined with sound absorbing materials. Bounding walls of enclosures should have adequate transmission loss to provide proper sound insulation (IS:1950).

Noise propagation can be controlled by installing machines on vibration-damping bases, using antivibration mountings and separate installation of noisy machines.

6.2 Substitution of Less Noisy Processes:

Examples are : Welding instead of riveting, mechanical forging instead of drop forging, grinding instead of chipping, belt drives instead of gears etc.

Other substitution includes hydraulic riveting instead of pneumatic riveting, grinding or flame gouging (20 dB) instead of chipping (120 dB), mechanical ejectors instead of air ejectors, slow acting process instead of high speed, hot working of metal instead of cold working, presses instead of hammers, rotating shears instead of square shears, belt drives for gears, pressing instead of rolling or forging etc.

6.3 Segregation and Isolation:

Noisy machines are removed to an area where few people work (segregation). Well insulated partition and tightly closing doors may be installed surrounding the machines (isolation).

Other isolations include providing a soundproof booth for the operator, separate location of noisy machines and processes from quiet ones -e.g. air compressor or diesel generator rooms should be separate and away from library, training centre, conference room, medical centre etc. Similarly office space should be segregated from the production area.

Equally noisy areas should be located together and segregated from quiet areas by buffer zones that produce and can tolerate intermediate noise levels.

Reflected sounds from ceiling and walls can be reduced by hanging isolators made of rubber, felt or cork.

6.4 Enclosure of Noise Source :

Noise producing operation can be enclosed or baffled in such a manner as to prevent dissipation of the noise into the surrounding area. Sound proofing by barrier structures.

Enclosures and barriers (partial or full, insulated or uninsulated, soundproof etc.) can curtail sound waves and reduce noise. More surface area of enclosure will reduce more noise.

A partial reduction of noise in certain directions can be obtained by one or more sided walls of barrier. Barrier wall facing the noise source should be coated with acoustic absorption material on that side to reduce noise appreciably. The barrier/enclosure opening should face a wall covered with sound absorbing material. If the top of the enclosure is open, sound absorbing material should be applied on the ceiling overhead.

Double wall with 10 cm intervening space is more effective than single partition of the same height.

Porous materials (e.g. porous concrete) can absorb more sound than rigid material.

6.5 Sound Absorption and Silencers:
(Acoustic Insulation)

High frequency sounds can be absorbed by applying sound absorbents to ceilings and walls in die form of acoustical tiles, plasters and blankets of porous materials such as glass wool. Acoustic baffles can be hung from the ceilings.

Reflection of sound waves from surfaces can be prevented by using absorbents which are usually porous materials that convert incident sound energy to heat. The amount of absorption depends on frequency and angle of incidence and can be expressed by the absorption coefficient which is die ratio of the absorbed energy to the incident energy.

A variety of absorbent materials are available for an acoustic engineer in the form of vegetable or asbestos fibres, glass or mineral wool and hard but porous plaster having less susceptibility to physical damage, fire resistance, light reflection, aesthetic qualities etc.

By sound absorbing walls, the operator near machine is not protected from noise, but the other workers working behind the walls would be benefited, particularly, if there arc reverberations 'in the building.

Application of acoustical material on ceiling and side walls, can reduce 3 to 8 dB noise level and bring down the general reverberate noise level to make the noise conditions less confusing.

Functional Sound Absorbers may be clustered as near the machines as possible. These units may be suspended and- distributed in any pattern to obtain lower noise levels within the machine shop. They are pyramidal or rectangular in shape. They use fibre glass as packing material. They have higher noise reduction coefficients than conventional acoustic materials placed directly on ceilings and walls. Noise reduction (absorption) coefficients are given in Table 12.9.

Table 12.9 : Noise Absorption Coefficients

Type	Coefficient for 250-2000 c/s
1 Flat area	
Fibre glass thickness	
2.5 cm	0.7
5 cm	0.93
2 Functional Sound Absorber	
(a) Pyramidal Shape	
Fibre glass	
Thickness	
2.5 cm	0.91
5 cm	1.39
(b) Rectangular shape	
Fibre glass	
Thickness	

2.5 cm	0.6
5 cm	1.18

Most of the construction materials (concrete, bricks, glass blocks etc.) absorbless than 2 % of sound energy incident on their surfaces reflecting the rest 98% back to the room. Note that the level of noise produced by a source located in the room is 5 to 15% higher in loudness than that produced by the same source in open.

The application of sound absorbing materials with high coefficient of sound absorbency for walls and ceilings permit the reflected noise to be diminished thereby reducing the total noise level in workroom.

Another benefit from sound absorption is the possibility of easy aural checking on operation of machinery because a direct sound from every apparatus or a machine tool installed in the enclosure can be detected by the ear easily.

Ceilings and upper portion of walls 1.5 to 2.00 mtrs above floor levels should be lagged (insulated) with sound absorbing material.

Best result can be achieved when at least 60% of total area of walls and ceilings are insulated.

Mufflers or silencers are also one type of sound absorbers. The velocity .and pressure of the air get reduced when it is routed through devious paths in the muffler components.

The mufflers are of two types. In absorptive or dissipative type a lining of absorptive material is provided and is protected by a perforated metal cover. Reactive mufflers are similar to electrical filters and give good reduction over a narrow range of frequencies by reflecting the sound energy.

The absorptive silencer has better performance at higher frequencies whereas the reactive type at low frequencies. Sound reduction or insertion loss increases with length, thicker splitters and reduced air gap.

6.6 Sound proofing :

Soundproofing includes construction or barrier structures such as walls or partitions, to safeguard the workers from external noise.

Sound proofing utilises the principle of reflection of sound i.e. the greater part of sound energy incident on a surface is reflected and only it's smallest part (l/ 1000 or less) penetrates through it.

In fact an ideal sound proof structure should not let noise into an enclosure it safeguards. More heavy (massive) the barrier-structure, the more soundproof it is. The sound proofness of barrier surface is determined by its acoustic in entrance. It is more sound proof to high frequency sound waves than to sound waves of low frequencies. Therefore the knowledge of the characteristics of sound is very important in sound proofing. In sound proofing following factors are required to be considered for obtaining desired results of sound proofing.

1. Intensity of sound.
2. Frequency of sound.
3. Co-efficient of absorbency of material used for sound barriers.

A higher co-efficient of sound absorbency is preferred to that of low coefficient in order to get good noise attenuation.

Adequate care should be taken to ensure that all openings in the noise enclosure should be properly sealed over entire area to prevent any leakage of unwanted sound through such openings. Doors and windows should be properly fit to match the perimeter and window frames receiving glass panels should be adequately shut. All such measures should be essential for efficient isolation of room with noise producing processes.

6.7 Ear Protection :

Personal protection should be used as a last resort. Ear plugs, ear muffs and helmets can be used by the exposed person for attenuation of noise to a safe level. Where noise levels are very high, better attenuation can be obtained by using both ear plugs and ear muffs.

If properly selected and used, personal protective equipment and devices, such as sound-proof head-sets (helmets), earmuffs, earplugs and noise stoppers can afford effective protection against noise disturbances and prevent various functional disorders. To the extent that accidents and hearing loss may result from exposure to excessive noise, these devices are a preventive measure, and can be used in addition to the principal noise control, measures when they are found ineffective.

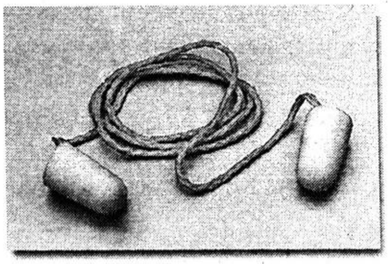


Fig. 12.10 Ear plugs

Ear plugs or defenders (Fig. 12.10) are the simplest, cheap and convenient devices used to reduce the harmful effect of noise. They are conical shaped plugs of various materials for insertion into the ear to reduce perception of noise, particularly impulse noise. They can be soft or rigid. Rigid plugs are made of rubber or plastic materials while soft plugs are of cotton cloth or of very fine glass cloth impregnated with oil or a waxy mastic. Plugs do not prevent the wearer from wearing headpieces or goggles. However, during long use, ear defenders may cause discomfort and irritation in the ear, particularly at elevated temperatures. Application of multi-use ear defenders requires special medical supervision.

Earmuffs (Fig. 12.11) are large pads of rubber or similar material attached to a band or strap and worn about the head for reducing the effect of noise on factory workers (during impact riveting, straightening, chopping and the like operations). The device is light, convenient to wear and effective against noise of high frequency which is exclusively harmful to the human ear

Fig. 12.11 Ear Protection (muff)

Head-niece or helmet is an effective device against the effect of noise levels exceeding 120 dB where the above protective devices are ineffective. High level of noise affects the skull causing the bones to vibrate. Such vibration adversely affects the auricular nerves and the brain function. Helmets provide adequate protection of the skull, particularly its paratideic region.

The systematic and correct use of ear protectors can prevent hearing loss and other noise induced health impairment.

The efficiency of ear protectors is expressed by the degree of attenuation of the noise penetrating into the external ear canal. Noise attenuation by ear protectors is limited by bone conduction for high frequencies and by skin resistance to low ones. Earmuffs offer higher attenuation than earplugs at the same frequency. Hearing protector's attenuation capacity is known as Noise Reduction Rating (NRR) and must be printed on the package.

Hearing protective devices are classified in four groups:

1. Enclosures (entire head) e.g. helmet.
2. Aural inserts e.g. earplugs - formable, custommoulded & remoulded type.
3. Super aural protectors - A soft rubber like material is held and inserted in the external ear canal. Band tension holds it inside (ear plugs).
4. Circum aural protectors e.g. earmuffs. Two cups are held by a spring-loaded suspension assembly or headband.

See Part 5.2 of Chapter-25 on PPE.

6.8 Rotation of personnel :

Since the effects of noise on hearing depend partly on the length of exposure, the bad effects may be reduced by removing the worker from the noisy environment wherever audiograms indicate a hearing loss.

See also administrative controls mentioned in Part 6.10. There rotation of noisy job or worker or dividing the noise period among one or more workers to reduce their exposure time are explained. Rotation of personnel or changing their work place should be done by taking their union in confidence so as to avoid any labour problem. As this is for the purpose of safety and health, normally they should co-operate.

6.9 Active Control (Antiphase) System:

Sound waves are intervened and obstructed by similar powerful sound waves to nullify their effect. Thus 'sound against sound' is the principle employed here. Reference microphone, error sensor and active control unit are used. Reference microphone detects the sound coming from source and supplies information to controller unit. This control unit with the aid of digital signal processing system, calculates the drive signals. Loudspeakers use these drive signals to give antiphase sound. Upper and bottom peaks of sound waves (cycles) are flattened. Bottom curves of drive (control) sound waves are thrown on the top curves of the sound waves to be absorbed. This modern system is useful to control noise from diesel engine, gas turbine, aeroplane, submarine and compressors.

6.10 Other control methods:

Most of the practical aspects to control noise at source are given in foregoing Part 6.1 to 6.9. Some other control methods are as under :

1. Substitution of non percussion tools and processes for pressure ones e.g. use of hydraulic drives instead of cam or eccentric drives and straightening instead of forged rolling etc.
2. Use of rotational, preferably uniform motion instead of reciprocating motions,
3. Use of vee-belt transmission instead of chain or gear transmission,
4. Use of lubricant baths for meshed gears and forced feed lubrication for articulated joints to minimise wear and noise caused by friction.
5. Use of lining and elastic inserts in joints to avoid or mininlise transfer of vibrations from one part to another.

6. Use of rubber lining for insides of metal containers and crates to be used for material handling.
7. Use of plastic and mute materials for metal or combination of metal parts with plastic.
8. Keeping fans and engines off when not in use.
9. Good regular maintenance by tightening loose guards and panels.
10. Oiling, greasing and replacement or adjustment of worn, loose or unbalanced parts of machines.
11. Reduction of forces and speeds.
12. Use of vibration dampers.
13. Reduction in radiating area and overall size.
14. Use of flexible mountings and couplings.
15. Use of resilient flooring and sound absorptive material on walls and ceiling.
16. Reduction in pressure, turbulence and increase in the cross section of the streams.
17. Elimination of air and steam leaks.
18. Increase in the distance from the noise source.

Care at the planning stage is more useful. Vendors and suppliers should be asked to provide information on the noise levels of currently available equipment. The inclusion of noise specifications in purchase orders is useful to get quiet equipment. If purchasers will insist, the designers will pay more attention on noise control.

Remote control of noisy equipment or its isolation in a separate room can control the exposure.

Administrative controls such as providing ear protection to workers, rotation of Jobs or workers in order to reduce their exposure times, transferring workers from high noise location to lower one for some period, scheduling of machine operating time so as to reduce the radiating time and also the number of workers exposed to noise, transferring more susceptible workers to less noisy area or dividing work at high noise level or extended period among two or more workers, if it may not cause any personnel problems.

Implementation of the legal standards and purchase agreements is also essential to reduce noise levels in all work places.

Despite of all efforts, periodical audiometric tests of workers working in high noise areas must be carried out and their records maintained.

7 AUDIOMETRY

In industrial situations pure tone audiometry for air conduction is carried out. An audiogram taken during the pre-placement medical examination serves as a reference level. Repeat audiograms can be taken at suitable intervals, depending upon the exposure to noise and the susceptibility of the person. Audiometry is useful in detection of hearing impairment at an early stage, evaluation of the ear defenders and evaluation of other control measures.

Zero dB is the reference level on the audiometer set as per 'standard' of the celebration. It indicates normal threshold hearing level of a healthy adult person as average of many tests. Now on test, if a person indicates 40 dB hearing threshold at 4000 Hz, 40 dB is a "hearing loss' or hearing, deficiency or 'hearing level' on that audiometer.

The audiogram serves to record the results of the hearing tests.

An audiogram: An audiogram (Fig 12.12) is a measure over a range of frequencies, of the threshold of hearing at which sound can Just be detected. Early deafness occurs in the frequency range of 2-6 KHz and is shown typically as a dip in the audiogram at 4 KHz. The depth of dip depends on degree of hearing damage and as this damage worsens, the loss of hearing widens to include neighbouring frequencies.

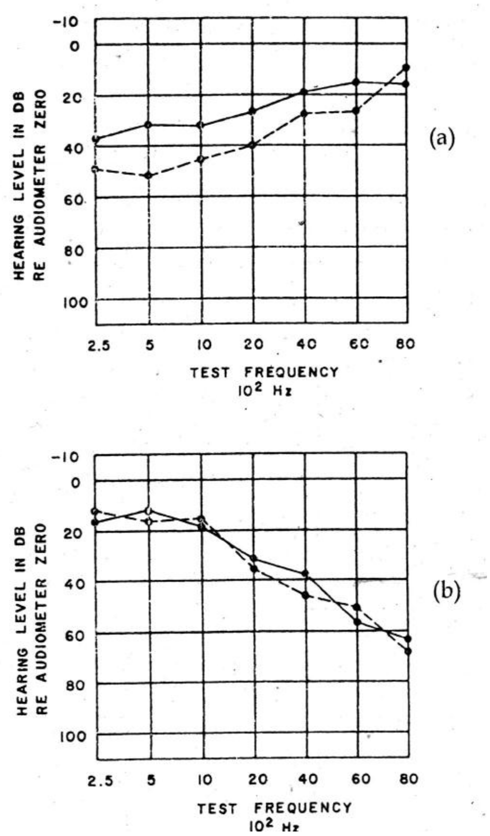


Fig 12.12 : Audiograms showing hearing loss of type (a) conductive and (b) Sensorineural

The advantages of an audiogram 'are that

1. It provides a baseline for future comparison.
2. It is helpful in job placement.
3. It can be used to detect early changes in hearing and in the diagnosis of noise induced hearing loss (deafness).

Audiometric Tests: Audiometric tests measure a person's threshold of hearing at selected sound frequencies. The test instrument is called an Audiometer and record obtained is called an "Audiogram".

The audiometer presents a variable sound pressure level in an earphone and measures at selected frequencies the minimum audible sound pressure level (threshold) that the person can bear and compare it with die average threshold of hearing of young person with no hearing impairment. The difference in decibels between the two thresholds is reported as hearing loss at each frequency and for each ear.

All employees are expected to show some hearing loss because there is a natural loss in hearing as we grow old.

Hearing tests or Audiometric tests are key to protecting all employees. It helps to identify those employees who are highly susceptible to noise induced hearing loss. So these individual can be given better protection long before their loss becomes permanent.

Audiometric tests are conducted on employees who work in high risk areas.

Benefits of Audiometric Tests are as under:

1. Pre-employment test helps employer to identify those employees who have developed hearing damage on account of prior job.
2. Periodic tests of employees exposed to low risk areas help detecting those employees who have developed hearing loss on account of off the job activities or medical disorders.
3. A baseline audiogram indicates individual's hearing ability at the time of the pre-placement examination. This can be compared with future tests results.
4. Provide a record of an employee's hearing acuity.
5. Check the effectiveness of noise control measures by measuring the hearing thresholds of exposed employees.
6. Record significant hearing threshold shifts in exposed employees during the course of their employment.
7. Help to decide about Hearing Conservation Programme.
8. Suggest need of appropriate ear protector or to suspend the employee from noisy atmosphere.
9. Compliance with government regulations.

An effective industrial audiometric program includes following components:

1. Medical Surveillance.
2. Qualified personnel.
3. Suitable test environment.
4. Calibrated equipment, and
5. Adequate records.

First engineering controls should be employed. Then ear protectors should be given. Even then the sound level is not within limit, period of exposure should be reduced as given in Table-12.5 or the workers should be transferred to less noisy area and audiometric tests should be carried out.

8 HEARING CONSERVATION PROGRAMMES

This requires two things (1) Noise surveys and (2) Audiometric tests of workers.

8.1 Noise Surveys:

Two types of noise surveys are carried out, preliminary and detailed. A hearing conservation program starts with a preliminary noise level survey where workers are exposed to high noise levels.

A noise survey becomes necessary where it is difficult to communicate in normal tones or where speech and other sounds are muffed for several hours or where workers develop ringing in their ears.

From the preliminary noise survey it becomes easy to determine where more detailed surveys are necessary. A detailed noise study should then be carried out at each such location to determine workers' TWA exposure.

Three steps are necessary for noise survey procedure

1. Area measurements.
2. Workstation measurements (to evaluate the noise exposure between 80 to 92 dBA).
3. Exposure duration.

8.2 Noise Conservation Programme:

Because of wide variations in human response to noise, it is unrealistic to set a limit which protects the vast majority of employees. Hearing conservation programmes are designed to ensure that all employees are protected.

A comprehensive hearing conservation programme calls for following:

1. Plant noise surveys to monitor noise exposure levels. Noise measurement, analysis and reduction by engineering controls.
2. Pre-employmentand periodic audiometric tests, record and audiograms and their evaluation.
3. Hearing protectors to workers exposed to 85 dBA or more.
4. Record keeping of workplace and noise exposure measurements.
5. Training to workers regarding such programmes.

Hearing tests, usually called audiometric tests, are the key to protecting all employees. Audiologists use them to identify employees who are highly susceptible to noise-induced hearing loss, so these individuals can be given better protection long before their loss becomes permanent. Audiometric tests are usually conducted at 6 monthly intervals on employees who work in high risk areas.

Hearing tests also provide other benefits. Pre-employment tests protect employers from assuming responsibility for hearing damage incurred on a prior job. Periodic tests, normally once a year, on employees exposed to low-risk environments can detect hearing loss due to off-the-job activities or to medical disorders.

An effective hearing conservation programme should be undertaken where exposure to industrial noise is capable of producing hearing loss. The object is to ensure that an employee's hearing is not affected during his working life to an extent greater than that usually occurring with age and to preserve it at a level sufficient for normal speech reception. Conservation programme is needed in situations where the hearing loss, as measured by audiometry, is more than 10 dB at 4000 Hz. It is also indicated when the sound level in the working environment is more than 90 dB and there is difficulty to communicate by speech.

9 WORKED EXAMPLES

Characteristics of sound waves

As sound energy is transmitted through a medium in waves, it exhibits certain properties. (1) The longitudinal waves travel at a velocity or speed. The speed of sound differs depending upon the medium of temperature and pressure in which it is traveling. At 0° C and one atmosphere of air pressure, the speed of sound is accepted as 331.3 ml/sec. As the temperature (T) increases, the speed of sound also increases at approximately 0.60 mt/sec for each 1° C.

Example-1 : What would be the speed of sound(s) at 20° C and 1 atmosphere?

$$\begin{aligned} S &= (331 + 0.6T) \text{ mt/sec} \\ &= (331 + 0.6(20)) \\ &= (331 + 12) \end{aligned}$$

= 343mt/sec .

Calculation of Sound Pressure Level

Lp = 20 log p/po Where, Lp = the sound pressure level, p= rms sound pressure, po= a reference sound pressure and log= logarithms to the base 10. The sound pressure level or Lp in a very quiet room, where the sound pressure is 0.002 Pa, is calculated: Lp= 20 log (O.OC2/ 0.00002) = 20 log (100) = 20 X 2 - 40 dB

Example-2 : Calculate sound pressure level of a typical gasoline-powered lawn cutter, which has a sound pressure of I Pa.

Sound pressure Level Lp = 20 log (1/0.00002) = 20 log (50 000) = 20 X 4.7 = 94 dB

Calculation of Sound Power Level

Sound power levels or Lw are determined by the following formula:

Lw == 10 log (Sound Power Level / Reference Power Level)

The reference power is one trillionth of a watt (0.000000000001 W). Therefore

Lw = 10 log (Sound Power Level / 0.000000000001)

Thus, the sound power level associated with an average whisper, which has asound power of 0.0000001 W, is calculated as

Lw = 10 log (0.0000001/ 0.000000000001) = 50 dB

Amplitude:

1. The amplitude of sound can be measured as an - intensity level (IL); although more commonly as the sound pressure level (SPL).
2. For an ideal point source in a free field (where the source is in open air or where reflection is limited) the intensity of sound radiated is given in following equation

1 = W/45 ϖ r2

Where: ‘I' is intensity of radiated sound

'W' is power (Watts)

'r' is the distance from the source (m)
Example of this type of noise may be a small loud speaker operating at low frequency.

Calculation (computation) of Noise Exposure

(1) For general classes of noise exposure -

When the sound level ,L is constant over the entire work shift, the noise dose, D in percent, is given by : D= IOOC/T

Where, C is the total length of the work day, in hours and T is the reference duration corresponding to the measured sound level (available from table or following formula) = 8/2(L-90)/5

Where, L is the measured A-weighted sound level, 90 is the criterian sound pressure level as per Factories Act.

(2) When the daily noise exposure is composed of two 'or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions :

C1/TI + C2/T2......... Cn/Tn exceeds 100 percent, then the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level.

(3) When employees are exposed to different noise levels during the day, the mixed exposure (Em) must be calculated by using the following formula:

Em= CI/TI •+ C2/T2 + C3/T3+ ...... Cn/Tn In this formula -

Cn - equals the amount of time an employee was exposed to noise at a specific level

Tn - equals the amount of time the employee may be permitted to be exposed to that level.

If the sum of the fractions equal or exceed 1, then, "the mixed exposure is considered to exceed the limit value.' Daily noise dose (D) is an expression of Em in percentage, eg. Em = I, is equivalent to a noise dose of 100 percent. Noise levels below 90 dBA are not considered in the calculation of daily noise dose.

Example-3 : A drill operator in underground mine is exposed to the following noise levels during the workday. Calculate the daily noise dose to him.

95 dBA for 2 hours, 90 dBA for 2 hours, 115 dBA for 0.25 hours

Thus, the daily noise dose is as follows:

D = 100 [2/4 + 2/8 + 0.25/0.25)
= 100(1.75)= 175%

Since the dose exceeds 100 percent, the employee received an excessive exposure during 1~ workday.

(4) The eight hour time weighted average sound level (TWA), in decibels, may be computed from the dose, in percent, by means of formula

TWA = 16.61 log10 (D/100) + 90

Where, TWA = 8-hour time weighted average sound
Level and D = Accumulated dose in percent exposure

Part B : VIBRATION

10 GENERATION, NATURE & TYPES OF VIBRATION

Vibration is a physical factor which acts on human body by transmission of mechanical energy from sources of oscillation.

Sources of oscillation may be knocks and friction of machine parts, unbalanced or inaccurately centred rotating parts, pressure pulses of compressed fluid etc.

Sources of vibration include

1. Rotation with unbalanced loads or bent shafts.
2. Misalignment of driving and driven parts.
3. Impact of a moving part against another part moving or stationary.
4. Water hammer in hydraulic systems.
5. High velocity air in ducts.
6. Looseness of equipment parts which causes them to rattle like shieving.
7. Lack of adequate snubbing devices in pneumatically operated equipment.
8. Flat spots or bend on bearings or steel wheels.
9. Worn or separated treads or nails or other objects embedded in tires.
10. Belt or gear slippage.

Vibration transmits more 'easily through solid materials than through air.

Frequency, amplitude and duration are the characteristics (nature) of vibration. Like noise, frequency is measured in cycles per second or Hertz. Frequency dial coincides with the body's own resonance tends to be the most uncomfortable; this being in the range of 2-30 Hz. Amplitude is the acceleration given by meters per second per second (rn/s^2) and denotes how far the surface moves each time it vibrates. Duration is the period how long it goes on. The longer is the exposure, the higher the risk.

11. EFFECTS OF VIBRATION

Types of vibrations are Whole Body Vibration (WBV) or Segmental or Hand Arm Vibration (HAV). Vibration of the whole body due to supporting structure (e.g. vehicle seat or a building floor) is of the former type while vibration of any body part (e.g. -hand or foot due to a vibrating tool) is of the later type.

Effects on Human Body : Effect on human body is due to frequency, amplitude and duration of exposure.

Vibration can cause annoyance and noise to human body and physical damage to machines and structures. Vibration can harm only if some part of the body is in direct contact with a vibrating surface viz. the seat of a vehicle or the handle of a power tool.

Effects of vibration are feeling of disoriented or displacement, giddiness, sickness, vibration disease and sometimes fatal. Whole body vibration can cause permanent damage to body or abdominal, spinal and bone damage. Vibration-induced White Finger (VWF) known as dead hand or Raynaud's Phenomena is a damage to the blood vessels and nerves in fingers due to a long use of vibrating power tools such as chipping hammers, chisels and drills.

Hand-arm vibration syndrome (HAVS) cannot be controlled by working within TLV only. Other control measures like use of anti vibration tools and gloves, proper work practices and medical surveillance program are also necessary.

TLV of vibration (HAV or WBV), as given by ACGIH Booklet (2007) is as under -

Total daily exposure time to vibration	Component acceleration which should not be exceeded	
	m/s^2	G
4 to less than 8 hrs	4	0.40
2 to less than 4 hrs	6	0.61
1 to less than 2 hrs	8	0.81
Less than 1 hr	12	1.22

$g = 9.81\ m/s^2$.

Human vibration resonance occurs in 4 to 8 Hz frequency range for Z-axis (vertical axis passing through human legs and head) and in I to 2 Hz frequency range for -X axis (across chest) and Y axis (across shoulders).

It causes numbness and blanking of the fingers with probable loss of muscular control and reduction of sensitivity to heat, cold and pain. It causes paleness of the skin due to oxygen deficiency. All vibrations make us tired or irritable.

Low frequency vibration (3-6 Hz) can cause diaphragm in the chest region to vibrate giving feeling of nausea. This resonance effect can be felt near large slow speed diesel engines and occasionally ventilation systems.

In 20-30 Hz frequency region, resonance effect on head, neck and shoulders, in 60-90 Hz, effect on eyeball and in 100-200 Hz effect on lower jaw and skull subsystem are reported. Normal ill-effects are possible in the range of 3-400 Hz.

The vibration causes the blood vessels to contract and restrict die blood supply, to the fingers creating an effect similar to the fingers being cold.

Localised vibratory effects may cause

1. Changes in bone - Decalcification in carpal bones which can be seen on x-ray.
2. Development of muscular weakness and degenerating alternatives in uluar and median nerves.
3. Muscular changes and muscle atrophy.
4. Ieuosynonities.
5. Dupuytreu's disease and
6. Cysts on some of the bones of the hand.

Initial treatment should be the rest and transfer to other work. .

Whole body vibration may cause

1. Increase in oxygen consumption.
2. Increase in pulmonary ventilation and cardiac output. Affects CNS, damages internal organs.
3. Difficulty in maintaining steady posture.
4. Effects on visual acuity and narrows the field of vision.
5. Marked changes in bone structure

- Spondylities.
- Deformations.
- Intervertebral Osteochondrosis.
- Calcification of the intervertebral disc.
- Schmorl's nodes.

6. Blood changes -
   - hypoglycaemia.
   - hypocholesteremia.
   - low ascorbic acid levels.

7. Alternations in the electrical activity of the brain.
8. Effects on endocrine, biochemical and histopathologic systems of the body.

As per ACGIH pocket book-2000, low frequency sounds -50 to 60 Hz (chest resonance range) - can cause whole body vibration, annoyance and discomfort. The SPL (sound .ptessure level) of such sound should be reduced to a level where the problem disappears.

Segmental vibration is a localised stressor creating injury to the fingers and hands of exposed workers using such vibratory hand tools as chain saws, pneumatic chopping hammers and picks and electrically operated rotary grinders.

Vibration may affect comfort, reduce work output and cause disorders of physiological functions giving rise to the disease in case of intense exposure.

At low frequencies (up to 10 Hz) the vibrations propagate through the entire body regardless of the location of input. In case of high frequency vibration, the zone of propagation is limited by the area of contact causing vascular disorders in that part.

Effects on Machines & Structure: Badly vibrating machines not only consume more power but also damage to the machine and its supporting structure. The vibrations also travel through the structure of the building and be radiated as noise at distant points. This is structure - borne noise.

Vibration causes metal fatigue which results in failures of rotating parts and other stressed mechanical equipment. It can cause rupture in a pressurised equipment, the higher the pressure, more chances a rupture.

See Part 4.1 of Chapter-17 also.

12 VIBRATING EQUIPMENT AND MEASUREMENT

Vibrating equipment include pneumatic, electric and petrol powered tools, pneumatic road breakers hammers, chisels and their variants, rotary rock drills air tools, rotary/percussive electric drills, riveting hammers, electric grinders, polishers, circular saws and petrol-powered chainsaw. Weaving looms, concrete mixtures (vibrators), tractors, threshers, some self propelled equipment, demolishing hammers, concrete breakers and nut runners also cause vibrations.

Czech limits for vibration are given in rms acceleration (m/ 2) for 8-hr exposure. Oscillator) velocity safe limits are also used.

13 CONTROL MEATHODS

Sound control methods described in parts 6.1 t(6.7 can also be useful to control vibration if properly applied.

Fig. 12.13 Vibration Monitor

Vibration monitors are available as shown in fig12.13 to measure level of vibration. They should be utilized for the selection of proper vibrating tool or equipment.

Main control measures are as under :

1. Vibration Isolators can effectively reduce transmission of vibration waves when properly install. This is isolation at source.
2. Reduction of Surface Response (Damping)' When isolation at source is not possible, vibration absorbers (Dampers) can be effectively used.
3. Reduction of Mechanical Disturbance that produce vibration. This is possible by reducing impects, sliding or rolling friction or unballance.

13.1 Vibration Damping:

Vibration dampers (absorbers) are used under machine foundation and the machine should be installed on an inertia block with a damping sandwich between it and the building foundation. But before this provision, efforts should be made to balance the moving parts of the machine which is the better remedy.

The method chosen should depend, on the size and weight of the machine, the frequency of the vibration to be controlled and the degree of isolation required.

13.2 Other Methods :

Vibration control measures include technical, organisational, hygienic, prophylactic and therapeutic measures.

(1) **Technical or engineering measures** include automation, remote control and eliminating or reducing vibration from the design stage or at source, use of vibration dampers, device for prevention, suppression, damping and insulation of harmful vibrations, use of automatic devices to avoid contact with the vibrating body, changes in the design parameters of machines, equipment and mechanised tools, static and dynamic balancing, selection of inertial and elastic parameters that avoid operation in regions of resonance, gyroscope installations to damp angular vibrations, active vibration (automatic suppression of vibration), 'acoustic . gaps' or movement arresters filled with a porous material, and a functional joint at the base-plate, elastic (deformable) inserts, vibration pads (supports), anti-vibration bushings, reduction in weight of hand-held machines etc.

(2) **Organisation measures** include good preventive and corrective maintenance and arrangement of work schedules in such a way to decrease time of exposure.

(3) **Prophylactic and therapeutic measures** – pre-employment and periodical medical examinations play an important role. Special gymnastics, hydrotherapeutic procedures, massage and UV radiation can prevent further development of vibration disease and preserve working capacity.

(4) **Special vibration absorbing handles** fitted to hand tools, springs, suspension seats and shock absorbers are useful.

(5) **Reduction in exposure time.** Rotate vibrative job and introduce rest schedules so that individual exposure is shortened.

(6) **Personal precautions** include watching for symptoms, to apply loose grip, to wear gloves and footwear with shock-absorbing soles to damp vibration to use PPE and to get medical attention.

(7) **Automation and remote** control system.

14 INDIAN STANDARDS

Some IS on Vibration are : Vibration and shock, vocabulary 11717, isolators 14259, vibrating feeder, mechanical 12401, vibrating screens - 12213, supplier's data sheet 8580, vibrating tables, concrete 2514, use 7246, vibration galvanometers 7889, measurement of human exposure 5349, whole body vibration 13276, 13281, vibration machine 10080, mechanical balancing 14280, measurement on rotating shaft 7919, vibration severity, measurement 11727, test optical instrument 10236, vibration dampers for overhead power lines 9708, vibrator pan 3366, purchaser's data sheet 8660, vibrator plate compactor 5889, vibrator roller 5500, 11391.

From above, IS 11717, 14259, 7889, 5349, 11727 and 10236 have general applicability and should be referred for details.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. What is sound and how is it perceived ?
2. What are the characteristics of sound?
3. What do you mean by 'loudness'? Does it depend on what? Give three examples of its levels in different industries.
4. Study reports showing the effects of noise on productivity.
5. What are auditory and non-auditory ill effects of noise?
6. Noise induced hearing loss and methods to measure it.
7. The results of a study of psychological effects of noise on steel workers.
8. What are the sources of industrial noise? Explain with examples.
9. Different methods of measurement of noise. What could ~be the objects of such measurement?
10. If you have to design a sound measurement report, what will be the contents?
11. What do you mean by recognition evaluation and control of noise hazards? Explain the steps and difference between them.
12. Factors affecting degree and extent of hearing loss.
13. What are the types and steps for noise surveys?
14. Various control measures for noise.
15. Different methods of noise control.
16. What do you mean by ear protection ? Explain the types of such protectors.
17. What is audiometry and audiogram? What does an effective audiometric program include?
18. The nature and types of vibration. The effects of whole body vibration. OR Segmental vibration (local effects) Different types of vibration control methods.

2. **Write Short Notes on :**

1. Nature of sound OR Generation of sound.
2. Types of sound OR Mode of sound propagation.
3. Types of hazards due to excessive noise.
4. Factors affecting effects of noise.
5. Damage Risk Criteria due to noise.
6. Meaning and types of 'hearing loss'.
7. Signs and symptoms of hearing loss.
8. Auditory fatigue OR Temporary Threshold Shift (TSS)
9. Masking as sound effect OR Noise control at source.
10. Effects of noise on human body.
11. Need or usefulness of measurement of noise.
12. Risk areas of noise measurement.
13. Noise dose and noise dose meters.
14. TLVs for noise OR TLVs for vibration.
15. Method to measure TLV for noise.
16. A noise dosimeter OR A sound level meter.
17. Types of sound measurement.
18. Noise (hearing) conservation program OR Meaning of dBA.
19. Statutory provisions for noise induced hearing loss.
20. Noise levels in public areas.
21. Noise exposure limits for continuous noise and impulsive or impact noise.
22. Sound absorption method OR Sound proofing.
23. Administrative control methods for noise OR Noise isolation.
24. Types of hearing protective devices and merits and demerits of them.
25. Antiphase noise control system.
26. Requirements of comprehensive hearing conservation program.
27. Benefits of hearing tests. OR Test cycle for hearing loss.
28. Effects of vibration on human body.
29. Sources of vibration.
30. Vibration damping OR Hand arm vibration syndrome (HAVS)

Reference and Recommended Readings

1. The Factories Act & Rules.
2. IS:3483.
3. Fundamentals of Industrial Hygiene, NSC, USA.
4. Safety Management, Grimaldi & Simonds, All India Traveller Bookseller, Delhi-110005.
5. Occupational Safety Management and Engineering, Willie Hammer, Prentice-Hall,
6. Encyclopaedia of Occupational Health & Safety, ILO. Geneva.
7. Handbook of Noise Measurement, Gross. E.E. Jr,, Concord, Massachusetts : General Radio Co. 1974.
8. Industrial Noise Control Handbook.
9. Useful Equations-Practical Applications of OH&S Math, 2nd Edition
10. Noise Control in Industry: A Basic Guide - Canadian Centre for Occupational Health and Safety.
11. Noise Control, by Emory E. Knowles III, Editor
12. Human Response to Vibration by Neil J. Mansfield

CHAPTER – 13

Fire and Explosion

THEME

1. FIRE PHENOMENA :

Fire is the oldest phenomena. People have seen fire since their existance. Controlled fire is a friend of mankind and is useful in many ways. It is an uncontrolled fire for which fire safety is required.

1.1 Nature of Fire :

Fire is an igneous element Whose potentiality is well recognised in our Indian culture. Like izdk'k (light), ok;q (wind) and ty (water), vfXu (fire) is our God and we worship them to protect us. They are the supreme elements and without them the human life is not possible. Olquka ikod'pkfe and vgefXu is said by Lord Krushna in Gita meaning thereby that he is vfXu amongst eight Vasus. ;K is the divine form of vfXu and through ;K we achieve everything.

The destructive nature of fire and need of protection is also explained as follows:

_.k'ks"k'pkfXu'ks"k% 'k=q'ks"kLrFkSo p A
iqu% iqu% izo/kZUrs rLekr~ 'ks"ka u 'ks"k;sr~ AA

Remainder of debt. fire and enemy grows again and again, therefore, they should be ended, not leaving any remainder. It is any remainder. It is explained earlier that u dwi[kuua~ ;qDra iznhIrs ofguuk x`gs i.e. it is of no use (too .late) to dig well when it is already fired in the home. Tims prevention is better than care and it is truer in case of fire prevention.

1.2 Need of Fire Safety :

Main object of fire safety is to protect life first and property next from the ravages of fire. Objectives of fire safety design are safety of life, protection of property and continuity of operations. Fire safety planning is required for sites as well as buildings. In industry, it is required for workers and public.

Potentiality of fire is tremendous as it holds the largest range of damaging capacity from a small burn to the disastrous damage of plants, persons and properties. Some glorying examples of fire and explosion are given in Table 13.1.

Table 13.1 Examples of Major Fire & Explosion.

Year	Plant & Place	Death	Serious Injuries
1942	Coal dust explosion, China	1572	-
1944	Ship explosion, Bombay	231	476
1947	Ship fire / explosion, Texas, USA	576	2000
1956	Truck explosion, Columbia	1100	-
1975	Mine explosion, Chasnala, India	431	-
1984	Petrol line fire, Brazil	500	-
1984	LPC fire, Mexico	500	7000
1993	Fire in a toy factory, Thailand	211	-
1994	Huge fire in oil refinery, Cairo, Egypt	132	-
1994	Fire in a dance hall, Beijing, China	233	16
1995	Fire in a moving train, Moscow, Russia	375	-
1995	Fire due to short circuit, Sirsa, Hariyana	368	-
1995	A leaking gas pipeline exploded, Taegu, South Korea	109	160
1997	Gas fire in pilgrims, tents, Mecca, Saudi Arabia	343	-
1997	Fire following explosion in a refinery, Vishakhapatnam, AP	60	-
1997	Fire while mopping up petrol spillage from a burst pipeline in Southern Nigeria, Egypt	500	-
1999	Gas explosion in a coal mine, Beijing, China	35	8
2000	Fire at Christmas party (discotheque) in lqoyang city in China on 26-12-2000.	309	-

Courtesy : LP News.

See also Table 13.9 for Explosion events.

Similarly some examples of estimated fire loss inferred from the fire insurance claims are given in Table 13.2.

Table 13.2 Examples of fire loss

Date	Place	Loss in Crore of Rs.
5-6-82	Calico Mills, Baroda	15.01
3-6-94	Parasrampuria Synthetics	13.32
5-12-94	Tata chemicals	10.00
18-11-95	Madras Refineries	51.60
14-12-95	Vikram Ispat	62.00
18-11-96	Fire on goods, train in Tunnel, France	366 USD
14-9-97	Fire at HPCL refinery, Vizag, AP	50

Courtesy: LP News.

These roaring figures of heavy losses of men and money strengthen the permanent need of fire safety. In industry, we store and use many materials which are capable of giving or catching fire. Many processes, equipment and situations create fire hazards. All these need proper detection and measures of fire prevention and control. This is in the interest of all.

1.3 Chemistry and Pyramid of Fire :

1.3.1 Triangle of fire.

According to old concept, three elements are necessary to start fire. They are (1) Fuel (2) Oxygen arid (3) Heat or Source of ignition. Fire is not possible if any one of these elements is not available. This is shown in figure 13.1.

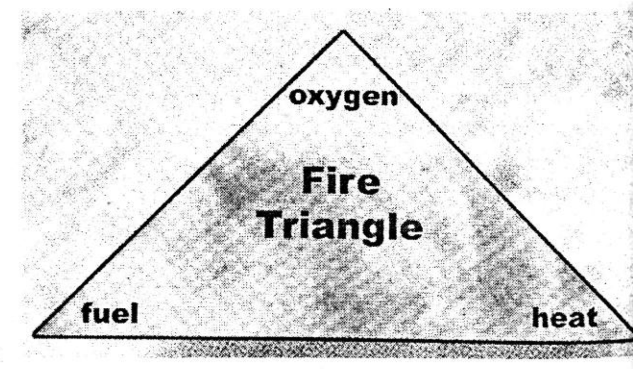


Fig 13.1 : Triangle of Fire.

1.3.2 Pyramid of Fire.

According to this concept, four elements are' necessary to start fire. They are as under

1. Fuel (combustible material and reducing agent).
2. Oxygen or oxidant or oxidiser (from the atmosphere).
3. Heat or source of ignition (necessary to start the fire initially, but maintained by the fire itself once it has started and
4. Chain reaction through free radicals to maintain the fire.

This is shown in fig. 13.2

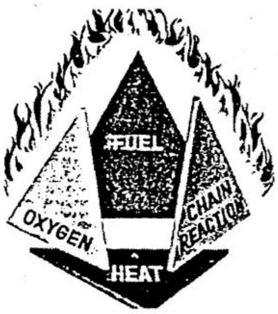


Fig. 13-2 : Pyramid of fire.

If any one of above four elements is removed, the fire goes out. Therefore methods of fire extinguishment are dependent on:

1. Removing or shutting off the source of fuel.
2. Excluding oxygen or decreasing it below 14 to 18% by adding inert gases.
3. Removing heat from the fire faster than its liberation and
4. Removing free radicals to discontinue chain reaction and flame propagation. Dry powder chemicals and halogenated hydrocarbons capture free radicals and put out fire in this way.

Thus fire is a rapid chemical oxidation reduction reaction. Oxygen in air acts as an oxidiser and fuel acts as a reducing agent and burning material. It is an oxidation of a substance (which burns ie fuel) accompanied by heat, light and flame. Due to incomplete combustion it evolves smoke and carbon monoxide which creates invisibility and toxic atmosphere for fire fighters.

An excess of air can cool the combustion gases to quench the fire, if the combustible material is small, otherwise it cannot, as in case of forest fire where the combustible material is too much to cool.

The chemical reaction is exothermic as it evolves heat and the heat released is used for the reaction to continue.

Fire is a burning or combustion phenomena and the combustion may be kinetic or diffusive depending upon homogenous or inhomogeneous air-fuel mixtures. The combustion may be complete or incomplete. The complete combustion gives product like CO_2, SO_2, water vapour etc., which cannot burn any more. The incomplete combustion (due to insufficient or blocked air) gives CO, alcohol, aldehydes etc., which can burn further more.

The amount of air required to burn 1 kg. of combustible material (or 1 m^3 of gas) is roughly given by $V = 1.12\ Q/1000$, where Q is the heat of combustion kJ/Kg. or kJ/m^3. Rate of burning also depends on the status of fuel i.e. solid, liquid or gas.

1.4 Stages of Fire :

Mostly fire develops in four stages as under

1. Incipient stage - No visible smoke, flame or more heat developed. Invisible combustion particles are generated over a period of minutes, hours or days. Ionisation detectors respond to these particles.
2. Smouldering stage - Visible smoke generation. Photoelectric detectors can detect this smoke.
3. Flame stage - Flame starts after point of ignition. Smoke decreases and heat increases. Infrared detectors can detect this stage.

4. Heat stage - Heat, flame, smoke and gases are produced in large amount. Thermal detectors respond to this stage.

See Part 5.2 for such types of detectors and alarms.

1.5 Spread of Fire :

It depends on the following factors :

1. The area of the substance exposed;
2. TT-ie amount of heat generated or given off by the burning substance;
3. The ability of the substance to conduct the heat away from the zone of combustion;
4. The atmospheric humidity and the wind velocity.

Thus fire will spread more if more combustible area is available, if more heat is: given by the burning material, if more heat conduction is possible and if atmospheric humidity is less and wind speed is high.

It is important to prevent or reduce the spread of fire. Following factors are useful in this regard.

1.6 Definitions :

To understand fire and explosion phenomena and their related subjects, following definitions are useful.

1. Auto-ignition (spontaneous ignition) temperature is the temperature at which a material will self-ig0nite and sustain combustion in the absence of a spark or flame.
2. Automatic Fire Alarm System is a fire alarm system comprising components and sub system required for detecting a fire, initiating an automatic alarm for fire and initiating other action as required.
3. Combustibility (Flammability or Ignitability) is the capacity of a substance to ignite and continue to burn in the presence of a heat source.
4. Combustion or fire is a chemical change (reaction) accompanied by the evolution of heat and light.
5. Control Centre is a permanently manned room preferably on ground floor within the premises at risk for the receipt of emergency calls and equipped with communications needed for transmission of calls for assistance to services, such as fire and police.
6. Detonation is propagation of flames following shock wave through pipes, vessels, etc., at a very high speed (supersonic) and high localised pressure.
7. Explosion is an extremely rapid chemical (explosive) transformation of fuel accompanied by release of energy and compression of gases capable of producing mechanical work.
8. Extinguishing media are agents which can put out fires. Common extinguishing agents are water, carbon dioxide, dry chemical, alcohol foam, halogenated gases (Halons) and water jel compound.
9. Fire or combustion is a rapid oxidationreduction reaction which results in the production of heat and generally visible light. A substance combines with an oxidant and releases energy. Part of the energy released is used to sustain the reaction.
10. Fire Alarm System is a combination of components for giving an audible and visible and/or other perceptible alarm of fire. The system may also initiate other ancillary action. It includes manual call points for initiating alarm.

11. Fire Point is the lowest temperature at which a mixture of vapour and air continues to burn when ignited.

12. Fire Resistance is the ability of an element of building construction, component for structure to fulfil, for a stated period of time, the required stability, fire integrity and/or thermal insulation and/or other expected duty in a standard fire resistance test (see IS 3809).

13. Fire Resisting Wall is a wall capable of specifying -the criteria of fire resistance with respect to collapse, penetration and excessive temperature rise.

14. Flammability limits (Explosive range) i.e. the values (upper and lower) expressed in percent by volume of fuel vapour in air, is the range of concentration within which a particular vapour or gas mixture with air will burn (or explode) when ignited. Below me LEL the mixture is too lean to burn and above the UEL it is too rich to burn.

15. Flameproof Enclosure is an enclosure for electrical machinery or apparatus that will withstand, when the covers or other access doors are properly secured, an internal explosion of the flammable gas or vapour which may enter or which may originate inside the enclosure, without suffering damage and without communicating the internal flammation (or explosion) to the external flammable gas or vapour in which it is designed to be used ' through any joints or other structural openings in the enclosure. (The term 'explosion proof is synonymous).

16. Flash back occurs when a trail of flammable gas, vapour or aerosol is ignited by a distant spark, flame or other source of ignition. The flame then travels back along the trail of fuel to its source resulting into fire or explosion.

17. Flash fire is vary rapid combustion.

18. Flash Point is the lowest temperature at which a liquid will give off enough flammable vapour at or near its surface, such that its mixture with air' can be ignited by a spark or flame. It is of more interest in safety than the fire point.

19. Fuel is a substance that acts as a reducing agent, giving up electrons to an oxidiser (e.g. Oxygen in air) in a chemical combustion. It may be an element like carbon, hydrogen, magnesium etc., a single compound like CO, methane CH,, a complex compound like wood or rubber or. mixture like LPG.

20. Ignition of a flammable mixture takes place when it comes in contact with a source of ignition with sufficient energy or the gas reaches an auto ignition temperature and self (auto) ignites.

21. Ignition Temperature is the lowest temperature at which ignition occurs in a mixture of explosive gas and air when the method specified in IS 7820 is followed. (Flash point is a higher temperature at which the most explosive mixture will ignite spontaneously on account of the environmental temperature).

22. Material Factor of a substance is a measure of its energy potential and is a function oi flammability and reactivity of the substance. The flammability depends upon the flash point or heat of combustion while the reactivity depends upon the instability of water. Higher is the Material Factor, higher is the fire and explosion hazard potential of a particular substance. For details see NFPA-704-M-1969.

23. Smoke Vents are openings, fitted with manual shutters for removal of smoke from a fire.

24. Spontaneous Ignition or Combustion occurs as the result of the gradual development of heat generation by chemical changes. For example, baggas (grass) cubes heaped to be used as fuel, generate sometimes, spontaneous combustion without spark and resulting into fire. Similarly oil soaked rags can sometimes ignite without spark due to combining with oxygen (oxidation), evolving heat and if the heat given off reaches the apparent ignition temperature of the rags it may burst into flame and result in fire. Water spraying can avoid such phenomenon.

25. Venting Fire is the process of inducting heat and smoke to leave a building as quickly as possible by such paths that lateral spread of fire and heat is checked, fire fighting operations are facilitated and minimum fire damage is caused.

1.7 Factors Contributing to Fire :

They are many. Some are easily detectable while some are hidden. Easily detectable factors contributing to fire are as under :

1. Easy availability of combustible material like rubbish, solvent, paper, wood etc.
2. Easy availability of air, oxygen or any oxidizing material.
3. Sources of ignition like spark, static discharge, contact of hot surfaces, friction etc.
4. Continuous running machinery without proper lubrication and maintenance.
5. Non flame proof electrical fitting in flammable areas.
6. Habit of smoking in flammable areas.
7. No provision of fire detectors in fire prone areas.
8. No provision of fire extinguishers in fire prone areas.
9. Open handling of flammable substances.
10. No compliance of fire safety rules. Some hidden factors contributing to fires are as under:
    1. Chemical reaction going out of control.
    2. Sudden stoppage of cooling media protecting flammable reaction or distillation of solvent.
    3. Trapping of metal parts, nails etc. in rollers or moving machinery giving sudden spark.
    4. Non availability of inert material on reaction of flammable substances.
    5. Sudden lightning from the sky.

1.8 Common Causes of Industrial Fire:

One study of more than 19000 fires in industrial plants revealed the following causes of fire:

Causes of Fire	%
Electrical	19
Friction	14
Foreign Substance	12
Open flames	9
Smoking & matches	8
Spontaneous ignition	8
Hot surfaces	7
Not determinable	7
Combustion sparks	6
Miscellaneous	5
Overhead materials	3
Static electricity	2
	100%

Another study of more than 25000 fires reported to the Factory Mutual Engineering Corporation from 1968 to 1977 gives following causes:

Causes of Fire	% Share
Electrical	22
Incendiaries (deliberate fire)	10
Smoking	9
Hot surfaces	9
Friction	7
Overheated materials	7
Cutting & Welding	7
Burner flames	6
Spontaneous ignition	5
Exposure	4
Combustion sparks	3
Miscellaneous	3
Mechanical sparks	2
Molten substances	2
Static sparks	2
Chemical action	1
Lightening	1
Total	100

Above percentage indicates the frequency of fire causes. It is not indicative of their relative importance at particular plant, place or property. These are old figures and old causes. Change in causes is always possible.

These causes can be subdivided in many sub causes as under:

Sparks may be mechanical, electrical, static, due to cutting and welding etc.

Hot surfaces may be due to bearings and shafting, stoves, heaters and small appliances, petrol, kerosene, LPG, acetylene or alcohol torches, potable furnaces, blow torches, smoke pipes, chimneys, flues and stacks, stationary heating devices, gas fired appliances viz. stoves, heaters, boilers, salamanders etc.

Spontaneous ignition is due to oxidation of fuel where air is sufficient but ventilation is insufficient to carry away the heat as fast as it is generated. Exposure to high temperature and, presence of moisture increase the tendency toward spontaneous ignition. We unslaked lime and sodium chlorate, rags or wash saturated with linseed oil or paint, sawdust, hay grains etc., and finally divided metals promote spontaneous ignition.

Hazardous chemicals and metals like phosphorous, sodium, potassium, oxidising materials nitro-cellulose film and pyroxylin plastics, fuels solvents, lubricants, wood, paper, cloth and rubber products, sprays and mists, LPG and other flammable or explosive gases are known for fire hazards.

Hyperboles, pyrophoric substances, adiabatic compression, radiation, catalytic action, natural sources, lightening, cooking equipment, electrical distribution and installation, static electricity, arson, rubbish, playing with fire, hand tools, pallet material storage and explosive dust, gas, vapour or air mixture are all causes contributing to fire.

Common causes of industrial fire and remedial measures are given in Table 13.3.

Table 13.3 : Causes of Fire & Remedial Measures

	Cause	Remedial Measure
1	Electricity	Standard and safe wiring, over load protection, double insulation and earthing on portable equipment, ELCB and waterproof cord in wet environment, use of proper flameproof equipment in hazardous area and periodical inspection.
2	Bad house keeping	Storing rubbish, waste, oil, grease etc. in a waste-bin with closed cover, regular cleaning and inspection, bund (dyke) to storage tanks of flammable liquid dust collectors, safe disposal, incineration.
3	Bidi-Cigarretts	No-smoking notices, separate smoking booths, checking of match box, lighter etc. at security gates.
4	Hot surfaces	Good insulation, fencing, ducting for smokes and flue.
5	Friction	Good lubrication, proper belt tension, alignment, dust removal, inspection and maintenance.
6	Excessive Heat	Cooling, temperature controls, trained operators and supervisors.
7	Welding cutting	Special place or partition, heat resistant floor, spark control, keeping flammable substance away, hot work permit, flammability test in tank before hot work, use of proper equipment.
8	Flame and combustion	Proper design, operation and maintenance, sufficient ventilation and ignition safety, heater insulation, hood, chimney, keeping flame away, trips and interlocks.
9	Self ignition	Keep environment cool and dry, necessary ventilation and protection, keeping ducts and passages of waste and smoke clean, separate store of highly flammable materials, not to put oil soaked rags on hot surfaces, lagging and cladding, small vessels, good house keeping.
10	Exposure	Barrier wall, sprinklers on fire path, wire glass in windows.
11	Ignition sparks	Proper equipment, closed combustion chamber, spark arrester on flammable vent and vehicle exhaust, flare, trip.
12	Mechanical sparks	Machine guarding to avoid entry of foreign particle, fencing, magnetic separator, non-sparking tools.
13	Molten hot substance	Proper equipment with handles, better operation, and maintenance non-mixing of water.
14	Static electricity (Due to belt drive, paper/ plastic reeling, human body, fluidized bed, pneumatic conveying, dust handling, liquid mixing, flow in vessel or pipe agitation etc.	Grounding, bounding, ionization and humidification, vehicle earthing while transfer through pipeline, earthing of vessel, equipment and piping, flow rate reduction, avoiding flammable atmosphere, splashing and settling, using earthed probe, antistatic device, conductive shoes and flooring, copper earthing with earth resistance less than 10 ohm additive to change liquid resistance, keeping filters away from storage tanks, extending inlet pipe up to bottom to avoid free fall of liquid, non-conductive parts and earthing of l4evel gauges, avoiding oil drops in water, small size of non-conducting plastic containers, using N2 instead of CO2 as inert gas, electrostatic eliminators on paper / plastic reeling machines, use of radioactive ionization etc.

2 CLASSIFICATION OF FIRE AND EXTINGUISHERS

Table 134 and 13.5 give the classes of fire (A to E) and portable fire extinguishers necessary for them.

Table 13.4 : Classes of Fire and Extinguishers

Class of fire	Description	Extinguishing Medium	IS No.
A	Fires involving ordinary combustible materials like wood, paper, textiles, fibres and vegetables etc. where the cooling effect of water is essential for the extinction of fires.	Water type (Soda acid)	934
		Water type (gas pressure)	940
		Water type (constant air pressure),	6234
		Anti – freeze types and	
		Water buckets	
B	Fire in flammable liquids like oils, grease, solvents, Petroleum products, varnishes paints etc. where a blanketing effect is essential.	Chem. Foam	933
		Carbon dioxide	5507 10474 2878 8149
		Dry Powder	2171 4308
		Dry Powder Mechanical foam	10658 10204
		Halon 1211	11108
		Sand buckets	
C	Fires involving gaseous substances under pressure where it is necessary to dilute the burning gas at a very fast rate with an inert gas or powder.	Carbon dioxide	2878 8149
		Dry powder Dry powder	2171 4308
		Halon 1211	11108
D	Fire involving metals like magnesium, aluminium, zinc, potassium etc., where the burning metal is reactive to water and which requires special extinguishing media or technique.	Dry powder	2171
		Special dry powder for metal fire	4861 11833
		Sand buckets	
E	Fires involving electrical equipment where the electrical non-conductivity of the extinguishing media is of first importance.	Carbon dioxide	2878
		Dry chemical powder	2171 4308
		Halon 1211	11108
		When electrical equipment is de-energised, same as for Classes A & B Sand buckets.	

* Class E is omitted is some literature (eg. IS: 2190)
Class K is suggested for fire involving cooking oils.

Note : For other IS see part 3.2 of this Chapter.

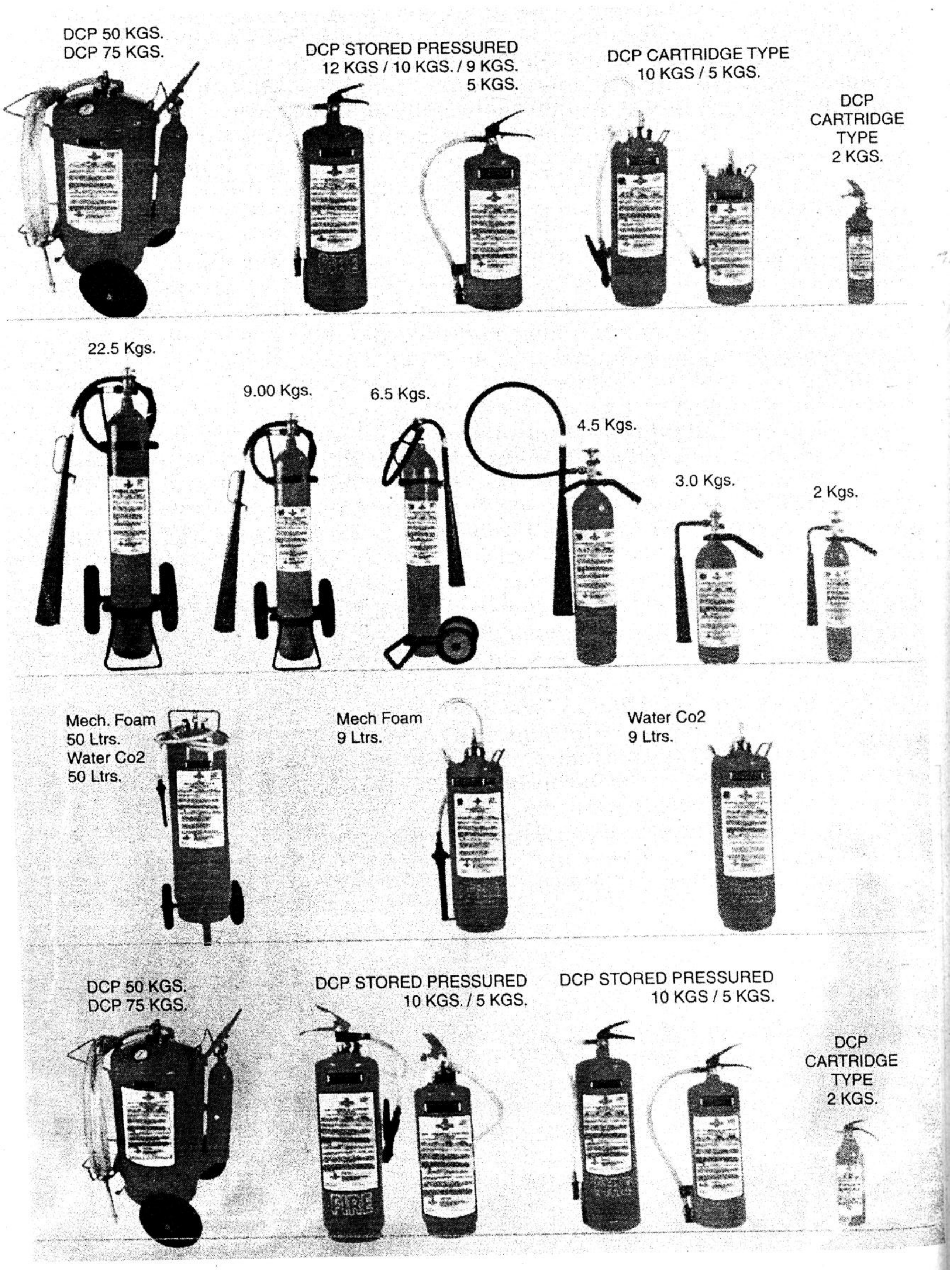


Fig. 13.3 Types of portable fire extinguishers.

Table 13-5 : Types of Extinguishers and suitability for Fire (IS:2190)

	Type of Extinguisher	IS No.	For type of Fires			
			A	B	C	D
1.	Water type (Soda acid)	934 4406	S *	NS *	NS	NS
2	Water type (gas cartridge)	940	S	NS	NS	NS
3	Water type (stored pressure)	6234	S	NS	NS	NS
4	Chemical foam type	933 5507 10474	NS	S	NS	NS
5	Mechanical foam type	10204	NS	S	NS	NS
6	Dry powder type	2171 10658	NS	S	NS	NS
7	Dry powder type	11833	NS	NS	NS	S
8	CO_2 type	2878 8149	NS	S	S	NS
9	Halon 1211 type	11108	NS	S	S	NS

* S = Suitable , NS = Not Suitable

See Part 5.4.1 for the use of fire extinguishers.

NFPA classification of Fire Extinguishers

NFPA 10 classifies fires and fire extinguishers into the following 4 types :

Class A : Fires in ordinary combustible material, such as wood, cloth, paper, rubber and many plastics, that require the heat-absorbing coolant effect of water or water solutions, the coating effects of certain dry chemicals that retard combustion, or the interruption or the combustion chain reaction by the dry, chemical or halogenated agents.

Class B: Fires in flammable or combustible liquids, flammable gases, grease and similar material that must be put out by excluding air (oxygen), by inhibiting the release of combustible vapor with AFFF or FFFP agents, or by interrupting the combustion chain reaction.

Class C : Fires in live electrical equipment. The operator's safety requires the use of electrically non conductive extinguishing agents, such as dry chemical as halon. When electric equipment is de-energized, extinguishers for class A or B fires maybe used.

Class D : Fires in certain combustible matals, such as Mg, Ti, Zr, Na, & K that require a heat absorbing extinguishing medium that does not react with the burning metals.

Class K : Class K fires involve cooking oils. This is the newest of the fire classes.

3 STATUTORY AND OTHER STANDARDS

3.1 Statutory Provisions:

Section 38 of the Factories Act requires to prevent outbreak of fire and its spread, both internally and externally and to provide and maintain (1) Safe means of escape for all persons in the event of fire and (2) The necessary equipment and facilities for extinguishing fire. Workers' training is also required.

Rule 66 of the Gujarat Factories Rules (GFR) requires sufficient fire exits, width and height atleast I and 2 meters respectively, one staircase for less than 20 workers on any floor and two staircases for more than 20 workers or explosive or highly inflammable materials on any floor and the availability of fire escape stair within 45.7 m. along the line of travel and at an angle less than 45° from the horizontal.

Rule 66A of the GFR : It provides as follows:

Various fire fighting arrangements are suggested under 13 heads. Two Schedules are given to list first aid Fire Fighting Equipment (FFE) and equipment to be provided with Trailer Pump. Their brief account is as under:

1 Serious Fire and Explosion Hazards :

1 All processes, storage, equipment, plants etc. should be in segregated buildings.
2 Minimum number of employees should be exposed at a time.
3 Fire prone area should be separated by fire resistant walls. It should be so constructed that in case of fire, it can be easily isolated.
4 Ventilation ducts, pneumatic conveyors, AC plant etc. should have flame arrester, flameproof damper or automatic fire extinguisher electrically interlocked with heat sensitive smoke detectors.
5 For storage of material, passage width between two piles should be more than 90 cm. and clearance between ceiling and the pile top should be more than 2 mt.

2 Access for fire fighting :

1 Unobstructed layout of plants and building for easy fire fighting.
2 Doors and windows on external walls for easy access inside the building.

3 Protection against lightening :

Lightening arrester shall be provided for
1 Building having flammable or explosive material.
2 Storage tanks for flammable liquids.
3 Grain elevator to avoid dust explosion.
4 Tall structure where gas, fume, dust, lint et may be present.
5 Electrical switchyard, outdoor transformers and substations.

4 Precautions against ignition :

Accumulation of explosive air mixture shall be avoided and prevented from fire by

1. Segregated electrical machinery or b keeping them flame or explosion proof.
2. Avoidance of static charge to a dangerous extent.
3. Non-ferrous shoes to avoid sparks b] friction.
4. Prohibition of smoking, lighting or carrying matches or lighters etc.
5. Transmission belts without iron fasteners

6. Avoidance of open flames, sparks, over heated surfaces, radiant heat and ignition from physical or chemical reaction.

5 Spontaneous ignition:

1. Avoid air pocket and ensure good ventilation.
2. Safe distance in heaps of material susceptible to fire.
3. Open ground storage at minimum distance of 10 mt from process or storage building

6 Gas Cylinders:

1 Rooms shall have adequate ventilation.

2 Open storage to be protected from direct sun-rays, excessive heat, continuous dampness and away from highly flammable substances, furnaces and hot processes.

7 **Storage of Flammable Liquids :**

1 Quantity minimisation.

2 Suitable containers with closed covers.

3 Liquid of P.P. below 21 °C shall not be stored more than 20 litres in any room.

4 Fire resisting construction with fire walls and self closing fire doors.

5 Storage of large quantities as per Petroleum Rules, 1976. Underground storage is preferred.

6 Steps to pre vent leakage.

8 Flammable dust, gas, vapour, waste etc. :

1 Steps to remove or prevent accumulation to dangerous extent.

2 Daily disposal.

3 Metal containers with covers.

9 Fire Exits:

An exit includes doorway, corridor and passageway. It should provide continuous (unobstructed) and safe egress (departure) by fire resisting wall. Lifts, escalators and revolving doors are not considered as "exits".

Some specifications of Fire Exits are as under:

1. They should be sufficient in number.
2. Clearly visible and illuminated. Lighting independent from normal power supply.
3. Marked by language understood by the workers.
4. Iron or spiral ladders not allowed.
5. Doors or roller shutters near lift or stair entrance should be of fire resisting type to prevent spread of fire or smoke.
6. All exits should reach open space leading to a street.
7. Should not be located at a travel distance exceeding 30 mt. For high hazard storage, distance should not exceed 22.5 mt and at least two escape routes should be available in each such room. Such more exits should be remotely placed from each other and providing access in separate directions.
8. Occupants per exit of 50 cm width shall be 50 for stairs and 75 for doors.
9. Area of 10 m2 per person or actual number of occupants as stated in (8) above, whichever is more, shall be considered to determine number of exits.
10. Every floor above or below the ground floor shall have minimum two exits. One of them should have internally enclosed stairway.
11. Minimum dimension of doorway - width 100 cm, height 200 cm.

12. Exit doorways should open outwards at all times. In an open condition it should not reduce the width of stairway or landing less than 90 cm. Overhead rolling shutters not allowed for this purpose.
13. Exit door should have a minimum landing of 1.5m x 1.5m on the same floor before opening on any stairway.
14. Exit door should be openable without key.
15. Width of corridor/passageway should no be less than total widths of all exit door opening on it. Height of corridor passageway shall be more than 2.4 mt.
16. If a staircase is arranged round a liftway, the fire resistance (rating) of the lift way should be more than that of the staircase.
17. Hollow combustible construction is not permitted.
18. Staircase dimensions -

Minimum width	100 cm
Minimum width of tread	025 cm
Maximum height of riser	019 cm
Minimum height of hand rail	100 cm

Treads should be non-slippery
Number of risers not more than 12 per flight

Hand rails should be firmly supported.
19. Use of spiral staircase is limited to low occupant load and for a building not higher than 9 mt. Its diameter shall, be more than 3 mt. with adequate headroom.
20. At least one fire door on the same floor should be of self-closing type.
21. Floor area on the opposite (shelter or refuge) side of a horizontal exit should be sufficient to accommodate occupants of the floor area served, allowing more than 0.3 1712 per person. At least one exit should directly lead to the street.
22. Ramp of slope I in 8, or less, be provided to connect floors of different levels.
23. A staircase may be substituted by a ramp of slope I in 10, or less. Surface of ramp should be non-slipping.
24. If the building capacity is more than 500 persons or if more than 25 persons are employed above or below the ground floor, an automatic or manual fire alarm system shall be provided.

10. First Aid Fire Fighting Arrangements :

Suitable and sufficient first aid fire extinguishers as prescribed in Schedule I (similar to Table 13.4) shall be provided and maintained. They should confirm to IS. Their numbers and types are classified for fire class A to E. They should be similar in a shape, appearance and method of operation. They should be placed in conspicuous place readily and easily accessible. Their bottom should be 75 cm above the floor level. They should be charged regularly and recharged immediately after discharge. Water and sand should be clean. One 9 litres water bucket should be provided for every 100 m2 of the floor area or part thereof. For details see Sch.l,Rule66A,GFR.

11. Other Fire Fighting Arrangements :

A formula is suggested to calculate the amount of fire water. If this requirement is 550 litres/min or more, power driven trailer pumps of adequate capacity are prescribed. Pumping capacity be reduced by 25% if fire service is available within 3 km. Each trailer pump should have equipment stated in Schedule-11. They should confirm to IS.

It should be housed in a separate shed close to a principal source of water and near the main risk of the factory. Towing attachment; one for every 4 trailer pumps is required, if manual pulling and placement of pump is not possible.

Water should be sufficient to supply at least for 100 minutes. At least 50% of the water requirement calculated by the formula or 4,50,000 litres whichever is less, should be stored in static tanks (each of 4,50,000 litres or more) distributed round the factory and in fire prone area. Diameter of main pipe should be more than 15 cm, capacity more than 4500 lit/min and pressure more than 7 Kg/cm^3

12. Fire Fighting Team, Drill etc. :

All fire fighting equipment (portable and fixed) shall be in charge of a trained person. Their number should be sufficient and provided with necessary clothing and equipment including helmets, belts, gum boots.

Quality of personal protective equipment (PPE) should confirm to the IS.

Fire drills are required at least once in two months or as often as necessary.

13. Hydrants and Sprinklers:

Fire hydrants and automatic sprinklers shall be in addition and not in substitution of above requirements.

See Petroleum Rules 2002 for fire safety of petrolium.

3.2 Indian Standards :

Fire : IS on fire safety are many. They can be selected as per requirement from the BIS Handbook. A few standards are stated below :

Glossary of terms for FFE 7673, 8757, Fire appliances, first-aid selection, installation and maintenance 2190, Fire bell 928, Fire brigade trailer pump 942, 943 & 944, Fire control equipment 10548, Fire detectors, heat sensitive 2175, Fire escape wheeled 931, Fire extinguishers, portable, CO_2, type 2878, Dry powder type 2171, Mechanical foam type 10204, 933, 4989, 4562, Water type (gas cartridge) 940, Water type (stored pressure) 6234, Water type, bucket pump 6924, gas pressure 940, Soda acid type 934, Fire extinguishing system, CO_2, fixed 6382, Fire fighting appliance, selection, operation and maintenance 5896, Extension ladders 930, Flame and heat resistant suit 7612 Water tender type A for fire brigade use 948, Gas cartridge for use 4947, Refills for portable fire extinguishers 5490 (Part I to 4), Twin CO_2 fire extinguishers (trolley mounted) 8149, 150 litre fire engine, foam type 10474, Higher capacity dry powder (trolley mounted) 10658, Portable-Halon 1211 type 11108. Fire tenders 946 to 951, 954 to 956, 2930, 6067, 10460,10993.

Automatic fire detection and alarm 2189, Heat sensitive fire detectors 2175, Hydrants in multi-storey building' 3844, Water supplies for fire fighting 9668, Automatic sprinkler heads 9972.

Hoses, Couplings, Accessories - 636, 884, 901 to 910, 926 to 928, 5612, 5714, 6026, 8090, Hydrant-stand post type 908, Stand post water monitor 8442, Hydrants and hose reels 3844.

Fire safety in building - 1641 to 1644, 1646, 1891, Ginning-pressing factories 2726, Welding & cutting 3016, Cotton textile mills 3079, Jute mills 3836, Storage & Warehouse 3594, fire resistance test 3808, 3809, tea factories 4886, fire retardant plywood 5509, saw mills and woodworks 6329, test for ignition temperatures 7820, paint and varnish factories 9109, chemical industries 11457, flour mills 13045, cable runs 12459, life saving equipment symbols 10548, LPG storage installations 6044, graphic symbols, 12307, safety signs 12349, gas testing flame safety lamps 7577.

Explosion : Some IS on explosion are: Classification of hazardous areas 5572, Exploders 9826. Explosion hazards - prolection against 8607, Explosive and accessories, blasting, tests 6609, Explosive atmosphere - electrical equipment 8239 to 8241, 7693, 7724, 8945, Explosive industry 11783, Explosives or pyrotechnic - glossary 10081, Packages 10212, dextrin 12276, Potassium nitrate 301, Sodium nitrate 12681, Ammonium nitrate 4668, Barium nitrate 4396, Aluminium powder 438, Barium chromate 7886, Lead chromate 7602, Manganese dioxide 5713, Calcium carbonate 7633.

See also Part-3 of Chapter-11 for electrical equipment to be used in flammable/hazardous areas. IS 5572 for classification of hazardous areas having flammable gases and vapours and IS 5571 for selection of electrical equipment for such areas are most relevant.

3.3 Guidelines of Regional Tariff Advisory Committee (TAC) :

Fire Protection Manual or Booklet on rules governing fire protection systems, was first published in 1906 by the Calcutta Fire Insurance Association and the edition of 1993 is published by the Oriental Insurance Co. Ltd., Bombay-20. The Committee means the Regional Committee at the regional office of the Tariff Advisory Committee .(TAC). The subjects of manual are as under:

Part I: Internal Appliances, Fire engines/Trailer pumps. Automatic fire alarm systems and Hydrant system.
Part II : Water Spray Systems.

Rules for Automatic Sprinkler Installations are also available.

Table of Contents of Part 1 is as under:

Fire engines, pumps, alarms and hydrants (TAC Rules):

1. Requirements regarding submission of plans
2. Procedure to be followed in the case of application for discounts
3. Committee's inspection staff
4. Internal appliances
   4.1 Hand appliances
   4.2 Small bore hose reels
5. Mechanically driven fire engines and trailer pumps
6. Rules regarding automatic fire alarm system using heat detectors
7. Hydrant service
   7.1 General
   7.2 Classification of occupancies
   7.3 Water supply
   7.4 Pumps
   7.4.1 General
   7.4.2 Steam driven pumps
   7.4.3 Electrically driven pumps
   7.4.4 Petrol or motor spirit engine driven pumps
   7.4.5 Compressor ignition driven pumps
   7.5 Mains
   7.6 Hydrants/fixed monitors
   7.7 Hose pipes and nozzles
   7.8 Foam compounds
   7.9 Fire fighting personnel
   7.10 Maintenance
   7.10.1 Pumps
   7.10.2 Mains
   7.10.3 Hydrants

Table of contents of Part II is as under:

Water Spray Systems (TAC Rules):

3.2.3 General Layout and Design
3.2.3.4 Projectors
3.2.3.5 Fire Barrier Walls
3.2.3.6 System Design
3.2.4 Detection system for transformers
3.2.4.1 Outdoor Transformers
3.2.4.2 Indoor Transformers
3.3 Miscellaneous protection

Section 4 - Medium Velocity Water Spray Systems
4.1 Introduction
4.2 Water Supplies
4.3 Pumping Capacity
4.4.4 Design density
4.4.5 Layout of protection network
4.4.5.7 Equipment protection
4.4.6 Structural protection
4.4.7 Piping and supports
4.4.8 Hydraulics
4.4.9 Detection system
4.5 Protection of Horizontal Cylindrical Storage Vessels
4.6 Protection of Vertical Cylindrical Storage Vessels
4.7 Protection of spherical vessels
4.8 Cable Galleries and Tunnels
4.9 Conveyors .

Section 5 - Pre-commissioning Procedures
5.1 Pre-commissioning and acceptance test
5.2 Periodical testing and maintenance
5.3 Periodical testing and maintenance chart
5.4 Hydraulic calculations General

Section 6 - General information
6.1 High velocity water spray system
6.2 Medium velocity water spray system
6.2.4 Scope of Applications
6.2.4.17 Limitations

Appendix -I, II & III

See Part 5.4.2 for further details of Water Spray System.

See Part 3.3 of Chapter-11 for the TAG Regulations for the Electrical equipment of buildings. TAC rules for Segregation of Buildings are also available.

3.4 NFPA Code (NFC) :

NFPA means National Fire Protection Association of USA. NFPA is an internationally recognised body and their standards, codes, and manuals are followed not only by American Government and industries but also by other countries in the world. NFC means National Fire Code.

The code indicates (1) relative risk to health (2) flammability (3) instability and (4) possible specific hazards (symbols) . Each of the first three aspects (1) to (3) is assigned a value in the range 0-4, the higher number indicating higher risk.

The content of the NFPA code (NFC) is vary exhaustive. A few subjects of 1990 NFC contents are given below:

Accreditation of Fire Protection Education Programs, Air operations for forest, bush and grass fires. Aircraft fire investigator's manual. Fire fighting at airport. Airport/community emergency planning, Alternative approaches to life safety. Ammonium nitrate-storage of. Baled cotton storage. Blower and exhaust systems. Building materials - test methods, fire retardant coatings etc.. Fire fighting in specific chemical industries. Protective clothing for fire fighting, Emergency voice/alarm. Cutting and welding processes. Fire extinguishers - different types. Electrical code - National, Electrical safety requirements, Explosion prevention systems. Fire department Occupational safety and health programs. Fire dept. – Safety officer. Fire detectors, hose etc.. Fire Inspector, Fire officer. Fire Prevention Code, Fire pumps. Fire services. Fireworks, Flammable and combustible liquids, gases, solids. Floor covering systems. Foam systems. Footwear, Fuel Gas Code-National, Hazardous materials incidents responders. Health care facilities. Homes and camps in forest areas. Hydrants, Life Safety code. Lightning Protection code, LNG and LPG storage and handling. Marine terminals, Breathing apparatus. Personal alert safety systems (PASS) for fire fighters. Places of worship. Property survey manual. Records-protection of , Roll paper storage. Roof coverings - fire tests of. Signalling systems. Smoke and heat venting. Spray and sprinklers systems. Static electricity. Symbols - fire protection, Truck fire protection. Venting of deflagrations. Water supplies. Wetting agents. Wildfire control. Wood dust explosion and Zirconium production processing.

Thus, NFPA code gives standards for many subjects on fire.

4 DESIGN FOR FIRE SAFETY

4.1 Fire Resistance of Building Materials :

In flammable area when building materials and paints are used, they should have good fire resistance. Steel and masonry are fire resistant materials. Fire resistive structural material should be selected depending upon the type of fire possible. There are three types of materials : (1) Non-flammable viz. metals, brick, clay, asbestos, concrete, cement, gravel, ceramics, sand etc. (2) Hardly flammable viz. staw brick, dry gypsum plaster, fibreboard, linoleum etc. (3) Flammable viz. organic origin such as wood, cardboard, felt, paper etc. As far as possible non-flammable material should be selected.

Fire or flame resistance is the capacity of structural element to perform its load-bearing and enclosing functions i.e. to retain its strength and ability to withstand action of fire, for a particular time during fire.

The fire resisting limits of buildings should be high to ensure safety and escape in case of fire. Such limits are measured in terms of time (h) from the start of the fire to the indication of any crack or loss of load carrying capacity (collapse) .or rise of excessive temperature. The fire resisting limits also depend on the size (thickness and cross section) and the physical properties of the building material. For example, 12 cm thick wall can withstand fire for 2.5 h and a 25 cm thick wall for 5.5 h. Fire retardant coatings on wood and flame proofing of fabrics are useful to some extent.

IS-.1642, 3079, 3594, 3808, 3809 and 6329 provide further details.

4.2 Fire Safety of Building, Plant, Exit, Equipment etc. :

The building should be protected both horizontally and vertically from spread of fire through floors, stairs, walls, ventilating ducts etc. Fire« resistant barriers can be used for this purpose.

A fire stopping is a fire-check wall of nonflammable material with a fire resistance limit of at least 2.5 h. It may be blind or with fire resisting doors or gates. Stopping can be internal, external, roof and separate (stand alone) fireproof walls. They are constructed to intersect the floors, ceilings and roofs with fibreboard of 30 cm over roofs from non-flammable materials. Fire-resistance limit of doors and gates in stopping should be more than 1.5 h. The total area of such openings should not be more than 25% of the total surface area of the stopping.

Where the construction of stopping is not possible, fire check-zones (strips of non-flammable materials) should be provided to divide floors and walls into sections more than 6 m wide. Ventipanes or smoke escape windows should be provided to facilitate smoke removal during fire. Exits and escape ways should be as per statutory requirement. Width of escape should be more than a meter and should increase depending upon the maximum persons likely to use it.

High fire risk areas; storage, packing and dispatch areas, boiler and fuel rooms, transformer room, kitchen and car parks should be separated by fire resistant construction. Storage of flammable liquids and gases should be minimum possible. Gas cylinders should be stored either in open air with shade or in a room of non-flammable construction and ventilated permanently to the external air. Fire hazards of storage of explosive and flammable substances, electrical equipment, static electricity, heating processes, painting, sparkling etc., should be foreseen and fully protected.

Lightening protection of buildings is most important as the heavy electric charge (up to 150000 KV and 200 KA) may prove destructive causing fir6 and explosion in the ground structure. Appropriate lightening arrester (protector) should be fitted higher than the highest' object and covering the lightening protected zone. The resistance of the grounding device should be less than 10 or 20 ohms depending upon its category.

Fire safety should be well thought of from siting: and location stage to the maintenance stage as follows:

Siting and location : sufficient space, water and emergency facilities, effects of past disasters, location of process areas for quick vapour dispersal and location of control rooms.

Plant layout : Segregation of hazardous processes and storage, drainage and compliance of statutory standards.

Design and Construction : Relief valves, by-passes, rupture discs, explosion vents, safety interlocks, flame arresters, flameproof fittings, selection of material, fire resistant construction, underground storage.

Plant Operation : Limited storage of flammable materials, good housekeeping, good ventilation, work permit system, emergency action plan and training of employees.

Plant Maintenance : Reliability and monitoring procedures, inspection, testing and preventive maintenance, spares availability and maintenance of fail-safe safety devices.

IS-.1642, 3594, 6329,1646 and 15:2190 must always be followed for material and details of construction of buildings, storage and use of portable fire extinguishers.

See Part 3.1 for statutory detail.

5 FIRE PREVENTION AND PROTECTION SYSTEMS

A broad classification of fire safety system is explained below:

- **Fire Safety**
  (Existence of fire hazard and awakening of fire consciousness of the management)
- Fire Prevention
  - Detection by Detectors (alarms)
  - Elimination of hazard or source of ignition
  - Control over combustibles in storage, handling and process
- Fire Protection
  - Fire resistant design of buildings, equipment , means of escape and fixed installations
  - Suppression, Extinguishment or control by various extinguishers
- Fire Fighting
  - Equipment and hardware
  - Staff, training and readiness

Above steps are explained below :

Fire prevention : This is an activity directed towards elimination of possible and potential sources of fires. It mainly indicates measures to avoid inception of fires. Where the source cannot be eliminated or avoided, exercise sufficient control to ensure its safe usage. The activity also involves control overhandling, storage and process of combustibles.

Fire Protection : This is an activity directed towards limiting the spread of fire to its place of origin by resorting to design , compartmentation, utilisation of fire resistive materials, provisions of safe means of escape, control by portable and fixed automatic extinguishing systems.

Fire protection being wider term includes fire prevention stated above and fire fighting mentioned below. Fire detection, prevention, extinguishment or control, all aim to protect plant, people and property.

Fire protection engineering is a highly developed specialised branch of engineering and a degree of B.E. (Fire) is awarded in college at Nagpur. Such qualified fire engineer and if he is not available, qualified safety officer should look after fire protection activities.

Fire Fighting : This is an activity directed towards provisions of proper fire fighting equipment, proper maintenance, personnel with proper organisation, training programme and readiness to fight fire.

Salvage : This is an activity to minimise the damage due to fire, smoke and water to the uninvolved property.

Return to normalcy : This is contingency plan where the various steps are laid down to bring back the industry, to productive stage from the crippling damage due to the fire.

Some systems are as follows :

5.1 General Control Measures :

Main steps in controlling fire are :

1. To detect the fire at the earliest possible.
2. To confine the fire, and
3. To extinguish the fire at the earliest possible.

Six fundamental principles of fire prevention and reduction are:

1. Fire prevention engineering.
2. Regular periodic inspection.
3. Prevent the start of fire.
4. Early detection and extinguishment.
5. Limiting the spread and damage due to fire and fire control.
6. Prevention of personal injuries from fire or panic, including prompt and orderly evacuation of personnel.

Based on fire chemistry explained in Part 1.3, four fundamental methods of fire control are :

1. Eliminate the oxygen of the air.
2. Remove or shut of the fuel supply.
3. Reduce the temperature below the kindling point and '
4. Break the chain reaction continuing the fire.

To achieve the most efficient fire protection system, involvement of the building designer(architect) and contractor, local authority (urban planer), interior designer, structural engineer, electrical engineer, fire detection system, manufacturer/supplier, building safety engineer and local fire marshal is necessary.

An automatic sprinkler system becomes most useful as it starts initially. Early detection of fire, speedy response, trained staff, emergency planning and preparedness and fixed extinguishing system based appropriately on fire load are the essential key points in any fire fighting arrangement.

To stop the fire occurrence, following fire prevention activities are desired:

1. **Fire Inspections :** Fire prone area, equipment and conditions should be inspected. Periodicity may be daily, weekly, monthly etc depending on requirement. A check list should be designed best fitting to the premises and activities. It should include checking of poor housekeeping, accumulation of dust or flammable material, readiness of fire hydrants, hoses, sprinklers, alarms, detectors, water storage, pumps/engines, charged portable fire extinguishers, foam, carbon dioxide, DCP and other protection systems, fire doors, aisles, exits, control room, electrical equipment, hot processes and machinery, and placement of fire fighting and personal protective equipment, tools etc.

2. **Hot-work permits :** Many fires have taken place while doing hot-work in flammable areas. A hot-work permit form and tag should be designed and used to check all points in advance and to take necessary precautions. Following steps are useful:

    1. Check the area where work is to be done.
    2. List steps, equipment and procedure necessary and prepare the permit.
    3. While at work, constant watch (supervision) is necessary if hazard exists.
    4. Standby workers should be ready on the spot with fire extinguishers.

5. Isolate flammable materials (stop its flow if possible) from sources of ignition.
6. Isolate sources of ignition by all possible ways.
7. Stop unauthorised use of spark producing equipment nearby.

3. **Fire brigade and Drills :** A plant fire brigade of qualified and trained personnel is necessary to fight fire till outside public fire brigade arrives and helps.

Regular scheduled training of all members of the unit should be carried out. On-site emergency plan involving other employees should be prepared and rehearsed.

4. **Fire-retardant treatments:** Such coatings can be applied on wood, plastics, paper etc. to withstand flame. Fire rating of such substances should be studied for comparison to the nontreated material. Chemical treatment to fabrics reduces their flammability. Flame retardant canvas can be used up to 250 °C. For higher temperatures, asbestos or chrome leather is preferred. Water gel compound can be used to soak a cloth-piece to make it fire-retardant. It should be noted that all such treatments are temporary and not foolproof.

5. **Communication :** After noticing a fire, fast communication is necessary, to call for fire fighting team and to alert occupants to the emergency. Well arranged bells, fire call buttons or a coded computerised fire alarm system are essential. Equally important is the training of persons to react after hearing the alarm.

6. **Protecting nearby buildings :** After noticing a fire, it is also necessary to protect the adjacent plant and building by closing windows, positioning personnel at each window nearest the fire, with fire extinguishers or fire hoses and stationing fire fighters on the roof of the exposed building with hose lines to keep the roof wetted and to put off any local fire.

7. **Assessment of Fire Risks :** For effective fire protection, it is necessary to analyse and evaluate the fire risk. Such process aims at -
   1. Recognition of hazards and potential hazards.
   2. Evaluation of hazards and expected losses.
   3. Evaluation of the proposed counter measures.

   A fire risk survey should be carried out to list fire hazards. Site, building construction, plant contents, management factors, people factors, fire protection system and post fire activities are the areas to be covered. Highly flammable material and processes, smoke and toxic gas generation, people likely to be affected, fire load calculation and specific nature or industry are relevant points.

5.2 Fire Detection and Alarm Systems:

Various types of detectors are available operating on principles of thermal expansion, thermoelectric sensitivity, thermo conductivity or photosensitivity to detect presence of smoke, increase in temperature, light intensity or total radiation. Their types are : Thermal expansion detectors. Radiant energy detectors. Light interference detectors and Ionisation detectors. They should be properly located depending upon their range. They simply give alarm and cannot extinguish fire. They make us alert for fire fighting.

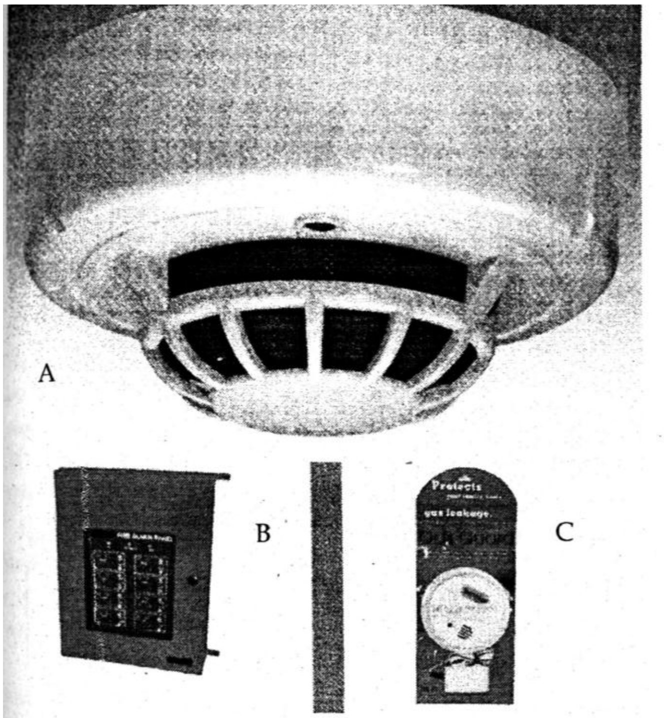


Fig. 13.4 Fire detectors (A & B) and LPG detector (C)

Fig. 13.4 Fire detectors (A & B) and LPG detector (C)

Though fire detection and alarm systems are separate systems but the latter has to operate just after the former operates. Therefore they are considered together. IS 2175 and 2189 also deal with them together.

Two main functions of any fire detection system are
1. To give alarm to start up extinguishing procedure, and
2. To give early warning to area occupants to escape.

It is wrong to speak 'fire detectors'. Actually they detect sensible heat, smoke density or flame radiation to operate before actual fire follows. Their 'sensor' detects measurable quantity of these parameters. A decision making device coupled with the sensor, compares the measured quantity with a predetermined ' value, and when it is different, an alarm is sounded. A detector both detects and signals.

Human being is a good detector as he can act m a flexible way i.e. run away, put out the fire or call the fire department. No other detector can work in such selective manner.

Selection of the type of detector is important For example, low risk areas need thermal detectors, a ware house may have infrared and ionisation detectors and a computer area requires ionisation or combination detectors.

Location and spacing should be determined to obtain the earliest possible warning.

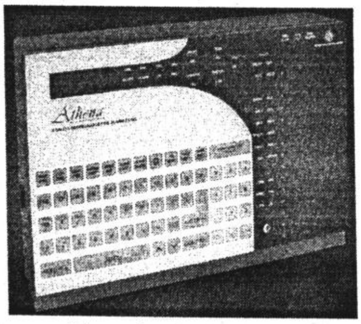
Sensitivity, reliability, maintainability and stability are important factors for selection.

Fire process has four stages - incipient stage, smouldering stage, flame stage and heat stage. Many types of fire detectors are available for various situations and useful at different stages of a fire (see part 1.4).

Thermal detectors are of fixed temperature detectors, rate-compensated thermal detectors, rate of rise thermal detectors, line thermal detectors and the bulb detection system.

Smoke detectors are of photoelectric type and are of two classes - The beam photoelectric or reflected beam photoelectric detectors.

Flame detectors are of infrared (IR) or ultraviolet(UV) type.


Fire alarm system

Ionisation (combustion products) detectors are the single chamber or dual chamber ionisation detector and the low-voltage ionisation detector.

Fire Alarm system may be separate to run manually or connected with fire detectors and operable automatically. All workers must be made aware of the sound pattern and its meaning. Fire alarm sound should be distinguishable from other sound m that area. It should be clearly audible to all facility personnel. Sound for beginning of fire and end of fire should be kept different.

5.3 Fire Load Determination :

After fire detection and alarm system and before fire suppression or extinguishing system, it is necessary to know the fire load so that based on that, amount of fire extinguishing system can be designed and number of fixed and portable fire extinguishers can be calculated.

Fire load is the concentration or amount of combustible material in a building per sq. mt. of floor area. It is defined as the amount of heat released in kilo calories by the fuel per square meter area of the premises. Fire loads are useful to calculate the water requirement to quench the fire, as when water comes in contact with burning surface it absorbs heat. I cc of water absorbs I cal of heat when the' temperature is raised by 1°C. The fact should also be considered that all the fuel does not burn at a time and all the water does not absorb heat as it flows away.

Bombay Regional Committee (BRC) on fire has prescribed rules for fire load calculation. Fire loads are calculated to assess potentiality of fire hazard, need of amount of fire prevention and protection systems (e.g. water or other agent) and amount of premiums required for fire insurance. Fire load classification is as follows:

Low fire load	-	Less than 1 lakh B.Th.U.
Moderate fire load	-	Between 1 to 2 lakhs B.Th.U.
Higher fire load	-	More than 2 lakhs B.Th.U

See Rule 66A(11) of the Gujarat Factories Rules for area calculation by ABCD formula.

For fire load calculation see-last Part 8.

5.4 Fire Suppression or Extinguishing Systems :

Mainly three methods are used in all such systems : (1) Starvation or isolation i.e. shutting off or preventing the flow of fuel and blanketing the fire surface with form to .seal air-vapour mixture (2) Cooling by application of water, foam or dry chemical powder and (3) Smothering by applying inert gas (to reduce oxygen), steam, dry chemicals or vaporising liquids such as C0,„ frecn FE 1301, methyl bromide etc.

Two types of extinguishers are used, portable and fixed.

5.4.1 Portable Fire Extinguishers :

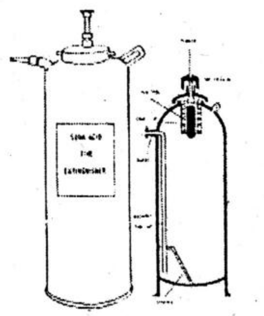
In addition to the fixed fire installations stated in next part, portable (first-aid) fire extinguishers are always desirable for quick manual use on small fires and fort the period till automatic equipment or outside fire fighters work. All such extinguishers should be (1) of reliable make, standard (IS) and properly identified (2) of right type depending upon the class of fire (3) sufficient in number (4) properly located where they are necessary and readily accessible (5) recharged periodically, inspected and maintained in good working condition and (6) known by the operators who are trained to use them.

Their types are : (1) Water type (2) Soda acid type (3) Carbon dioxide type (4) Foam type (5) Dry chemical powder type and (6) Vaporising liquid type. IS:2190 is most useful for selection, installation and maintenance of portable first aid fire extinguishers. Details of these six types are also given in IS:940, 6234, 934, 2878, 933 and 2171. Tables of their suitability according to class of fire and scale i.e. their range or area coverage arc also given therein. Based on them, number of extinguishers can be determined. Methods of their testing and test form are also prescribed. Refer them for further details.

See Table 13.4 and 13.5 for selection of portable extinguishers.

For small fires mostly portable fire extinguishers are used. They are explained below in brief:

(1) Soda Acid (Water Type) Extinguisher:



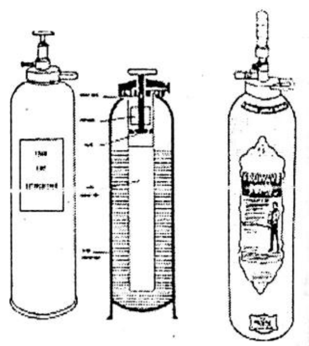
Soda Acid (Water type) extinguisher

This extinguisher is useful for class A fire (wood, paper, fabrics, rubbish etc.). It should not be used on fires of electricity, oil, chemical or metal. It is available in both the shapes cylindrical and conical.

Its normal capacity is 9 Ltr (weight 14 Kg) and to be used in a range of 6 to 8 mt. It consumes within I to 1.5 minute. It should be checked every 3 months.

It is held vertically up (not inverted). By standing 4 to 5 mt. away from the fire, after opening the plunger, it is struck on the hard surface. A small H„SC) (Sulphuric acid) bottle breaks and due to its mixture with soda bicarbonate solution, C0„ (Carbon dioxide) is generated. Pressure of CO, throws water at a distance. Its handle and bottom are held by two hands and water is sprayed on fire to extinguish it.

(2) Foam Extinguisher:



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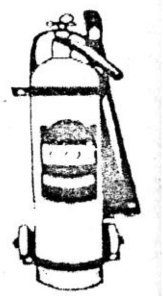
It is used on class B small fires. It: should not be used on electrical or metal fire. It is available in 9 Ltr cylinder and used in 4 to 6 mt range. It consumes within 1.5 minute. It is available in wheel mounted trolley of 18 Ltr and 150 Ltr capacity for longer use. It should be checked every 3 months.

By standing 3 to 4 mt away from the fire, the plunger is. pulled up and turned right up to a slot. It is shaked by turning 180" twice. Then it is held inverted. By chemical reaction CO is generated which throws foam outside. The foam is not thrown directly in fire but it is thrown on nearer hard surface so that because of striking further foam is generated and spread on burning surface. It stops oxygen availability for burning and controls the fire. Foam is effective up to 120 °C temperature only.



CO_2 Extinguisher

(3) CO_2 (Compressed gas) Extinguisher :

It is useful on class E i.e. electrical fire because CO_2 is nonconductive gas. It can be used on class B and C fire also, as it diminishes oxygen to control fire. It is not advisable to use it in a closed room as more CO_2 may be inhaled. Therefore open doors and windows before using it in a room. It should not be used on fires of metal, sodium, potassium and metal hydrides.

It is available in 2 kg ,4 kg, 6.8 kg and 22.5 kg capacities. Small cylinders have handles and big cylinders have wheels. Its range is 1 to 1.5 mt. CO_2 pressure is at 64 to 70 bar. It should be checked every three months.

(4) Dry Chemical Powder (DCP) Extinguisher :

This can be used on any class of fire. Therefore it is known as 'universal type extinguisher'. It is generally used on fire of flammable liquid. It is not effective on fire of benzene, ether, EO and CS_2 For metal fire, special powder extinguishers are available. 1,2,5 and 10 kg extinguishers in cylinders and 68 kg in wheel models are available.

A 10 kg cylinder is consumed within 12 to 15 seconds and its range is 3 to 6 mt. A 68 kg cylinder is consumed within I to 1.5 minute and its range is 6 to 8 mt. Both should be checked at 3 months interval.

By standing 6 to 8 mt near the fire, the cylinder is shacked twice by turning 180°, a safety clip is removed and plunger is pressed or struck so that CO, bottle breaks and it throws dry chemicals out. The dry powder blankets the burning surface, stops 0, contact and CO, coming out also diminishes 0 proportion. Therefore fire is controlled by double action. Its long nozzle should be turned in wind direction like a broom.

DCP extinguisher

(5) Halon Gas Extinguisher (Halon Alternatives):

Halon 1011, 1211 or 1301 a liquid gas is filled in extinguishers. It is used in place of CO, extinguishers but is lighter in comparison. 1.5 ,3 and 6 kg cylinders and bigger sizes are available in wheel mounted model. By pressing a knob in cap-assembly it can be started. Nose should be covered to avoid direct inhalation.

It is suitable for class B and C fires. See IS 11108 for Halon 1211.

Halon is a fast extinguishing agent. It is ideal for intense and rapid fires. It is non-conductive and leaves no traces when applied. Therefore it is also suitable for electrical fires, computer rooms etc.

Halon interrupts the chain reaction at the flame zone of fire. It is two times as effective as CO_2 on a weight basis and five times as effective as CO_2 on volume basis.

Halon is stored under pressure in a cylinder. A squeeze grip type nozzle is provided on top of the cylinder valve depending upon capacity. It is available in 2,4,5,25 and 50 kg capacities. Mostly two types of Halons (halogenated agents) are used as they are less toxic - (1) Halon 1211-Bromochloro difluromethane i.e. CF_2BrCI and (2) Halon 1301 - Bromotrifluromethane CF_2Br.

5.4.2 Fixed Fire Installations :

Fixed automatic fire installations are desirable from the design stage, as they can be used for longer time and are more effective than the portable type.

(1) Fire Hydrants :

Fire hydrants are economical and should be installed freely around the plant. They should be kept accessible, unobstructed and protected for safety. Indicator posts are advisable.

Fire hydrants, hoses, nozzles and couplers are part of the system. Fixed nozzles are single or double headed. Monitor nozzles are on swivel joint and can be turned as desired and to clear any obstruction. Hose nozzles can be extended and laid (i.e. more flexible) wherever required. They are of fixed flow type, adjustable flow (variable discharge) type and a combination type.

The number of hydrants needed depends on the fire exposure and the hose-laying distance to the built-up areas. The discharge ports should be at least 18 inch (45 cm) above the ground level.

Fire Hose and Nozzles of standard size, double jacketed rubber-lined should be stored in hose boxes and should be subjected to a full pressure test once a year. Space around hose lines and control valves should be clear. Aisles and door ways should be wide enough and clear to allow rapid use of hose reel cart or mobile equipment.

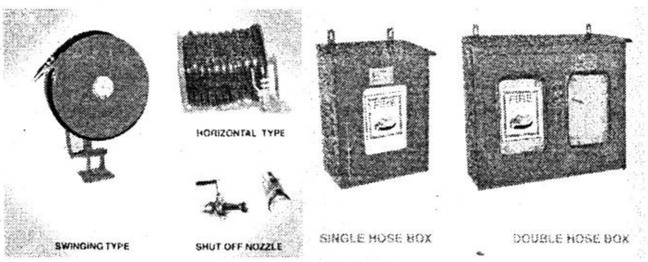


Fig. 13.5 Hoze reel, Hoze Box and Nozzle.

Monitor Nozzles are used in yards and large congested areas where it is difficult to lay hose line in an emergency. The nozzle is so positioned to direct a high pressure water stream over desired area and height.

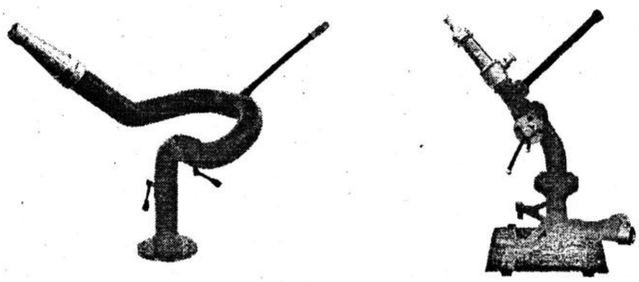


Fig. 13.6 Fixed monitor & Portable Ground Monitor

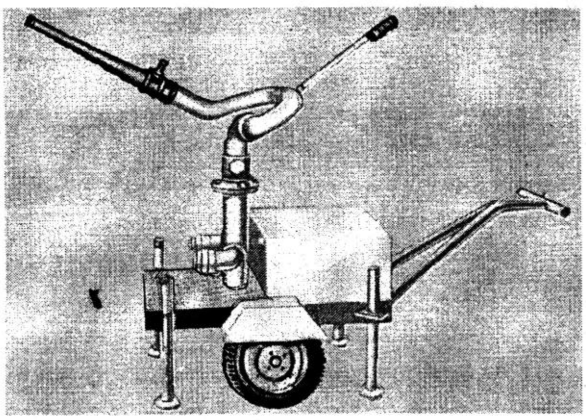


Fig. 13.7 Trolly mounted water monitor.

Water Reservoirs are necessary for the supply of fire water at good pressure and volume. They should not be used for other purposes such as process requirement. If the reservoir is common, suction pipe (its bottom end) for process water should be at a higher level than the suction pipe for fire water into the bottom of the reservoir to maintain the level of reserved water for fire protection.

Water Supply from reliable sources is essential. Reservoirs, overhead tanks, pressure tanks, pumps, pipes and connections must be maintained well. Flow discharge may vary from 10 to 40 litres per second and pressure from 7 to 10 kg./cm2.

TAC guidelines(rules) for water supply for hydrants are as under :

Water for the hydrant service shall be stored in any easily accessible surface or underground lined reservoir or above ground tanks of steel, concrete or masonry. The effective capacity of the reservoir(above the level of the foot valve seat in case of negative suction and above the level of the top of the pump casing in case of positive suction) for the various classes of occupancies (as per rule 7.2) and size of hydrant installations shall be as indicated in Table 13.6 hereunder:

Note 1: Reservoirs of and over 2,25,000 litres capacity shall be in two interconnected compartments to facilitate cleaning and repairs.

Note 2: Large natural reservoirs having water capacity exceeding ten times the aggregate water requirements of all the fire pump drawing there from may be left unlined.

Table 13.6 : Capacity of water storage

Nature of Risk	Capacity of static storage exclusively reserved for hydrant service.
1. Light Hazard	Not less than 1 hour’s aggregate pumping capacity with a minimum of 1,35,000 litres.
2. Ordinary Hazard	Not less than 2 hour’s aggregate pumping capacity.
3. High Hazard (A)	Not less than 3 hours’ aggregate pumping capacity.
4. High Hazard (B)	Not less than 4 hours’ aggregate pumping capacity.

Note 1 : The capacity of the reservoir for Ordinary and High Hazard Class Occupancies may, at the discretion of the Committee, be reduced by 2 hours' inflow from a reliable source (other than a town's main) but in no case shall the reservoir capacity be less than 60% of that mentioned above.

Note 2 : In case of Light Hazard Class Occupancies the minimum capacity of the reservoir shall be increased to 2,25,000 litres if the highest floor of the building is more than 15 mt above the surroundings ground level.

The capacity for hydrant service shall be determined by the class of occupancy and size of installation as per Table 13.7.

Table 13.7: Pump, Capacity and Delivery Pressure :

Sr. No.	Nature of Risk	Number of Hydrants	Pump Capacity in Litres / Sec (m^3/ hour)	Delivery pressure at rated capacity kg/cm2
1	Light hazard	i) Not exceeding 20 ii) Exceeding 20 but not exceeding 55 iii) Exceeding 55 but not exceeding 100 iv) Exceeding 100	27 (96) 38 (137) 47 (171) 47 (171) plus 47 (171) for every additional 125 hydrants or part thereof.	5.6 7 7 7/8.8
Note : The total pumping capacity need not be greater than 190 (683) irrespective of the number of hydrant points.				
2	Ordinary Hazard	i) Not exceeding 20 ii) Exceeding 20 but not exceeding 55 iii) Exceeding 55 but not exceeding 100 iv) Exceeding 100	38 (137) 47 (171) 76 (273) 76 (273) plus 76 (273) for every additional 125 hydrants or part thereof.	7 7 7 7/8.8
Note : The total pumping capacity need not be greater than 302 (1092) irrespective of the number of hydrant points.				
3.	High Hazard (A)	i) Not exceeding 20 ii) Exceeding 20 but not exceeding 55 iii) Exceeding 55 but not exceeding 100 iv) Exceeding 100	47 (171) 76 (273) 114(410) 114(410) 114(410) for every additional 150 hydrants or part thereof.	7 7/8.8 7/8.8 7/8.8/10.5
4	High Hazard (B)	i) Not exceeding 20 ii) Exceeding 20 but not exceeding 55	Two of 47 (171) Two of 76 (273)	7 7/8.8

		iii) Exceeding 55 but not exceeding 100 iv) Exceeding 100	Two of 114(410) Two of 114(410) plus one of 114(410) for every additional 200 hydrants or part thereof.	7/8.8 7/8.8/10.5

This provision will apply only in cases where the hydrant service has been hydraulically designed as per NB 3(13) u/r 7.5.10.

Note: In case of Light Hazard Occupancies, the pump delivery pressure will need to be 7 kg/ cm2 if the highest floor of the risk is at a height exceeding 15 mt above the surrounding ground level:

Proper drainage facility shall be provided to drain the fire-fighting water out of the basement.

Storage of material in the open shall be protected as under:

Metals, Metallic goods, Machinery and goods, Machinery and other non-hazardous storage.	One single hydrant for every 60m. of the storage periphery located beyond 2 m., but within 15 m. of storage area.
Coal or Coke	One single hydrant for every 45m. of the storage periphery located beyond 2 m., but within 15m. of storage area.
Other storage	One double hydrant for every 45 m. of the storage periphery located beyond 2 m., but within 22.5m. of storage area.

Note 1: In case of open storage areas of following materials, at least 50% of hydrants shall be replaced by fixed monitors having nozzle bore of 38 mm diameter if the individual stack height is more than 6 m. and total storage exceeds 5000 tonnes.

Bamboo Bagasse.
Grass/Hay Timber.

Note 2: Where hydrants/monitors located along one longer side of a storage area are more than 90 m. from those along the other longer side, such a storage area shall not be deemed to be protected.

Protection for combustible/flammable liquid Storage Tanks:

Tank less than 20 m. in diameter.	One double headed preferably two single headed hydrants located beyond 15 m., but within 35m. of tank shell.
Tanks over 20 m. in diameter.	Two double headed or four single headed hydrants located beyond 15 m. but within 35 m. of tank shell.

Note 1: In case tanks are located more than 22.5 m. from the dyke walls, one double hydrant or two single hydrants shall be replaced by a 38 mm monitor.

Note 2 : Where the distance of tank from the monitor exceeds 45 m. in addition to provisions of Note I, the tank shall be protected by Fixed Foam or Medium Velocity Water Spray System having prior approval of the Committee.

Note 3 : Hydrants/Monitors shall not be installed within dyked enclosures nor can the hydrant main pass through it.

Note 4 : Fixed roof type storage tanks, floating roof type storage tanks exceeding 30 m. in diameter and Bullets/Spheres containing products having flashpoint below 32 °C shall be protected by Medium Velocity Water Spray System conforming to relevant regulations.

However, manually-operated systems shall also be acceptable.

Water spray systems shall not be insisted for Insulated Vessels/Spheres."

"Water spray protection for small size tanks up to 10 mtr. diameters in ordinary and high hazard risks shall not be insisted upon."

(2) Automatic Water Sprinklers :

They are of six types. Wet pipe, dry pipe, pre-action, deluge, combined dry pipe and pre-action and sprinklers for limited water supply system. Automatic alarms operated by the flow of water should be a part of sprinkler installation. Such an alarm may be connected to a central fire station. The sprinklers should be regularly checked to avoid their failure to work.

Automatic sprinklers are most efficient and widely used. It reduces insurance premium considerably.

Its basic function is to spray water automatically to a fire, the system can also work as a fire alarm. This can be done by installing an electrical water flow alarm switch in each main riser pipe.

Sprinklers should be selected on the basis of temperature rating and occupancy. Their types are Either heat-element or chemical melts or expands to open the sprinkler. Normal detector setting is 68 °C. Sprinklers heads normally cover 12 m3 per head. Amount of water required depends on risk protected, flow range being 0.04 to 0.514 I/m'

In deluge system, water is admitted to sprinklers that are open at all times. Deluge valves (water supply valves) can be operated manually or automatically by an automatic detection system.

Maintenance and inspection of water supply valves, system piping for obstruction, nozzles and water supply tests etc. are necessary.

(3) Water Spray System :

Water spray system uses water in small droplets through special nozzles giving various pressures. The system is supplemented to and not a replacement for automatic sprinklers. It should be checked that the water should not be reactive with the material burning.

The system is similar to the deluge system except that the open sprinklers are replaced by spray nozzles. The system is generally applied to flammable liquid and gas tanks, piping and equipment, electrical equipment such as oil filled transformers, switches and motors. To avoid short circuit, current should be cut off before applying tile spray.

The spray nozzle holes are smaller than those in ordinary sprinklers, therefore they can be choked. To avoid this, strainers (filter or screen) are required in water supply lines. The nozzles having the smallest holes, have their own internal strainer in addition to the supply line strainer.

TAC guidelines on Water Spray Systems give retailed rules. Some extract is given below:

Definitions and terminology relating to the components of the water spray systems are as follows:

(a) **Water Spray System :** A special fixed pipe system connected to a reliable source of fire protection water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface or area to be protected. The piping system is connected to the water supply through an automatically actuated Deluge Valve which initiates flow of water. Automatic actuation is achieved by operation of automatic detecting equipment installed along with water spray nozzles. There are two types of systems namely High Velocity and Medium Velocity systems. The former is useful for liquids with flash point above 65 °C and the latter for flash point below 65 °C.

(b) **Spray Nozzle and Valves :** A normally open water discharging device which, when supplied with water under pressure will distribute the water in a special directional pattern peculiar to the 'particular device. Nozzles used for High Velocity Water Spray systems are called "Projectors" and nozzles used for Medium Velocity Water Spray systems are called "Sprayers". Both these nozzles are made in a range of orifice sizes with varying discharge angles so that discharge can be controlled for optimum protection.

Different types of valves are used with fire water piping system or water hydrants as shown in fig. 13.8.

(c) **Deluge Valve :** A quick opening valve which admits water automatically to a system of projectors or sprayers and is operated by a system of detectors and/ or sprinklers installed in the same areas as nozzles.

(d) **Control of Burning :** Application of water spray to equipment or areas where a fire may occur to control the rate of burning and thereby limit the heat release from a fire until the fuel can be eliminated or extinguishment effected.

(e) **Exposure Protection :** Application of water spray to structures or equipment to limit absorption of heat to a level which will minimise damage and prevent failure whether source of heat is external or internal.

(f) **Impingement:** The striking of a protected surface by water droplets issuing directly from projectors and/or sprayers.

(g) **Run Down :** The downward travel of water along a surface caused by the momentum of the water or by gravity.

(h) **Slippage :** The horizontal component of the travel of water along the surface beyond the point of contact caused by the momentum of water.

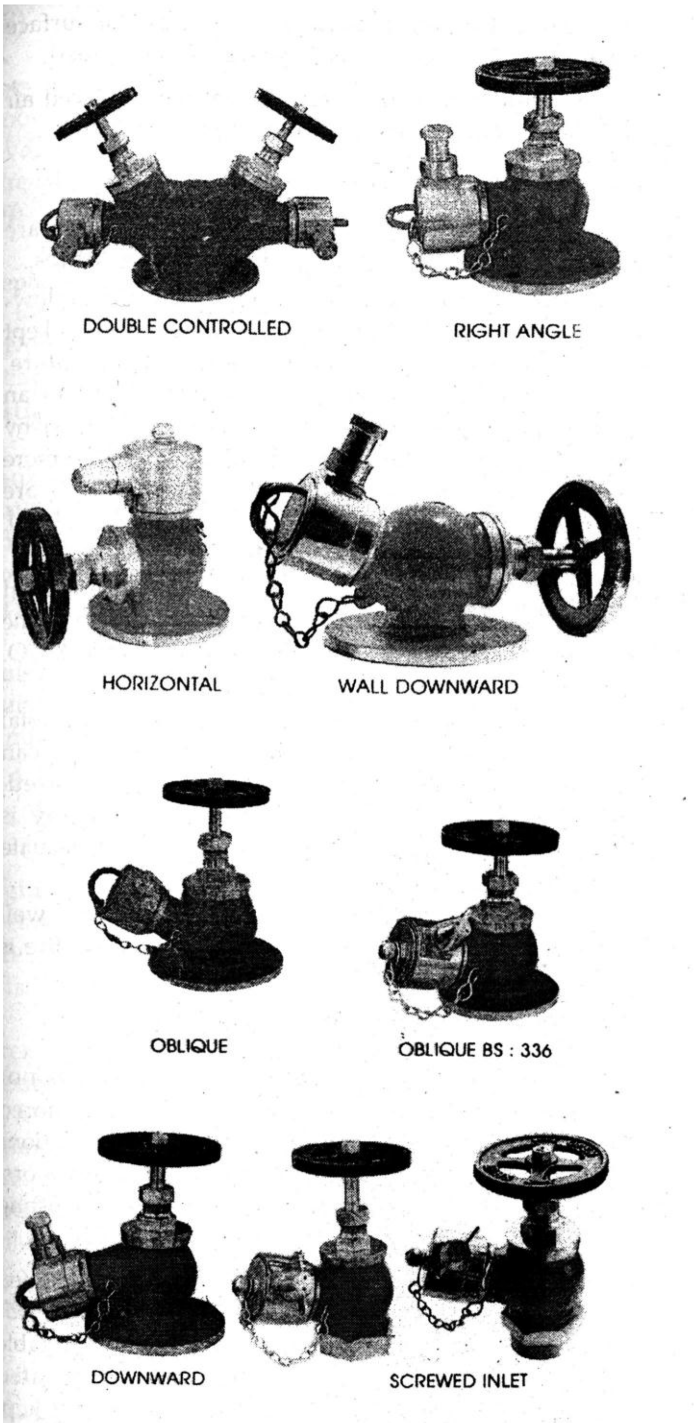


Fig. 13.8 Types of valves.

(i) Insulated Equipment : Equipment, structure vessels provided with insulation which for the expected duration of exposure, will protect steel from exceeding a temperature of 454 "C (850 °F) for structural members and 343 °C (650 °F) for vessels.

(j) Density : The unit rate of water application to an area or surface expressed in litres/min/ m

(k) Automatic Detection Equipment : Equipment which will automatically detect one or more components directly related to combustion such a heat. Smoke, flame and other phenomenon and automatic actuation of alarm and protection equipment.

(i) **Fire Barrier :** It is a continuous wall or floor that is designed and constructed to limit the spread of fire.

(m) **Range Pipes :** Pipes on which sprinklers are attached either directly or through short arm pipes which do not exceed 30 cm in length.

(') **Distribution Pipes :** Pipes which directly feed the range pipes.

Testing and maintenance of water spray system is given m Table 13.8.

Table 13.8 Periodical Testing and Maintenance Chart

Sr	Subject	Activities	Duration
1	Reservoir	Level checking	Weekly
		Clearing	One in 2 years
2	Pump	Running test	Daily
		Test flow	5 minutes
		Lubrication	Annually
		Gland	Quarterly
		Packing	Weekly
		Overhaul	One in 2 years
3	Engine	Running	Once in day (5 mins)
		Fuel tank check	Daily
		Lubrication	Quarterly
		Battery status	Weekly
		Load test	Annually
		Overhaul	Once in 2 years
4	Motor	Lubrication	Weekly
		Starter contact checking	Weekly
		Insulation resistance check	Half yearly
5	Main piping	Gauge pressure	Check daily
		Flushing	Once in 2 years
6	Sluice valves	Operation	Monthly
		Gland packing	Monthly
		Lubrication	Quarterly
7	Deluge valves	Operation	Weekly
		Alarm check	Weekly
		Cleaning	Quarterly
		Overhaul	Annually
8	Sprayers	Cleaning	Quarterly
		Flow test	Quarterly
9	Detectors	Performance	Six monthly
10	Spray installation	Performance	Quarterly
		Physical check up of piping for seeing dislocation of support, wrong orientation overloading etc.	Monthly
11	Pressure gauges	Calibration	Annually
12	Painting of entire installation		Every 2 years

(4) **Foam System :**

It uses fixed foam apparatus either automatic or manual. It may consist of one or more portable foam extinguishers suspended in such a way that flame or heat releases a cord or fusible link to operate the extinguisher automatically. Discharge rate may vary from 15 to 4000 gpm. Foams are of two types - chemical and mechanical. Chemical foam is produced by a chemical reaction of CCX, bubbles and a foaming agent. Mechanical foam is created when air and water are mechanically agitated with a foam solution.

Fire fighting foam (gas-filled bubble solution) is lighter than most flammable liquids. Therefore it forms a floating blanket on burning liquid, cuts off oxygen supply and also cools the fuel.

Foam system is generally used to protect fuel tanks, oil and paint storage rooms, asphalt coating etc. It can be injected on the liquid surface in a tank to provide blanketing effect and to cut off flames and vapours.

Foam is of two types - Low expansion and High expansion foam. Low expansion foam is of four types Chemical foam, Mechanical -or air-generated foam, Protein foam and Synthetic (fluorinated surface active agent) foam. Foam generators of different types are available.

Foam-water sprinkler and spray systems use mechanical foam equipment with a deluge sprinkler system.

High-expansion foam is best suited for class A and B fires in confined spaces such as sewers, basement. It is made by mixing a small amount (@ 1.5%) of foam liquid into a foam generator where water and large quantities of air are mixed. Accumulated foam can act as an insulating barrier for the surface not involved in fire. Thus it prevents fire spread.

Ventilation is necessary to vent the displaced air and gases when foam is being applied.

(5) Carbon dioxide systems :

These are fixed, local or flood type. They are generally useful for electrical, liquid and gas fires.

CO_2 system may be of high-pressure or low pressure type. In the high pressure system, CO_2 is kept in a compressed gas cylinder at normal temperature, while in the low pressure system, it is stored in an insulated pressure vessel at —18 °C and 300 psi by mechanical refrigeration. At such low temperature more CO_2, can be stored economically. Safety valves are provided to take care of refrigeration failure. Liquid CO_2 can bedelivered through nozzles at 15 kg/sec.

In both the systems, CO_2 can be released manually or automatically through nozzles close to the expected source of fire. Unlike water or chemical, CO_2 does not spoil the stock or equipment.

In a room, compartment or small building, total flood system can be used where wall openings can automatically be shut when the gas is released. Warning alarm to alert people working nearby is necessary. Sufficient time must be allowed to evacuate the area.

In a confined place, the area should be well ventilated and checked for 0, content after the fire is extinguished.

(6) Dry Chemical Powder (DCP)

Dry Chemical Powder is neither toxic nor conductor of electricity, nor does it freeze. It is stored in an inert gas cylinder under pressure. Installations can be provided for simultaneous closing of fire doors, windows, ventilating ducts, operating valves, shutting off fans and machinery and actuating alarms.

The dry chemical piped systems are developed for fast extinguishment in a confined area or for localised application. They are useful on flammable liquid and electrical hazards and can be operated manually, automatically or remotely. The agent is kept in a pressurised container fixed or mounted on vehicles.

Action of extinguishment is to interrupt the chain reaction of fire by the dry chemical agent.

Dry chemicals include Sodium bicarbonate as standard dry chemical. Potassium bicarbonate. General purpose powder (ABC) and Monnex powder. If electrical equipment is not involved, foam can be used to follow DCP application.

(7) Vaporising Liquid system :

It uses carbon tetrachloride, methyl bromide or chlorobromo methane as an extinguishing agent. All these being toxic, care in handling (with PPE) is essential.

(8) Steam System :

It uses automatic or manually controlled steam jets to smoother fire in closed containers or small rooms. It is practicable where continuous steam is available. It is not effective on deep-seated fires. precautions against burns should be followed.

(9) Inert Gas System :

It uses CO_2, N_2, flue gas or other inert gas to replace O_2, in air. Oxygen should be reduced between 5 to 16%, depending upon the combustible material involved. After the use, the place should be thoroughly ventilated and tested for normal oxygen for re-entry.

(10) Air Agitation :

It uses air or other gas injection to induce in the tank or container an upward flow from the colder (bottom) surface to the burning (upper) surface, thereby cooling the surface. Generally this system is useful for small oil fires in tank or container.

(11) Drenchers :

Drenchers in roof, wall or window throw water outside the building to protect it from fires coming from outside. A drencher system is made up of water heads similar to sprinklers.

5.4.3 Automatic Fire Detection and Extinguishing System:

This system is the latest development in fire fighting techniques in European countries. With fire trace trade name it is used to detect and extinguish fire directly at the source automatically, quickly and efficiently.

It can be used at any type of fire risk. Its pressurised flexi-tube delivery system is leak resistant, flexible, temperature sensitive and rupturing at 100 °C to form a distribution nozzle that delivers pressurised extinguishing media (foam) directly on the source of fire. It is a self contained stand alone system. Its operation is not affected by power or water main failures. It reacts reliably every time.

This system is of two types, direct release system and indirect release system.

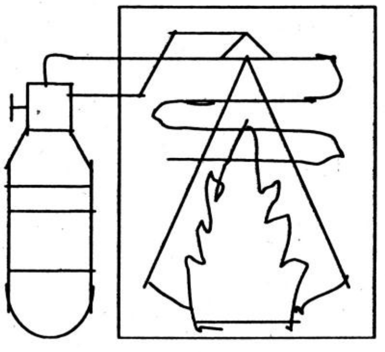


Fig 13. Direct Release System

In a Direct Release System the same tube is utilised for both the detection device and extinguishing delivery system. The portion of the tube nearest the hottest point of the fire ruptures at 100 °C forming an effective spray nozzle. The pressure drop in the tube releases the entire contents of the cylinder through the distribution nozzle to extinguish the fire. More tubes can be used to cover more area.

In Indirect Release System the detection tube ruptures at 100 °C and the resulting pressure drop causes the indirect valve to activate diverting flow from the detection tube to the larger outlet ports.

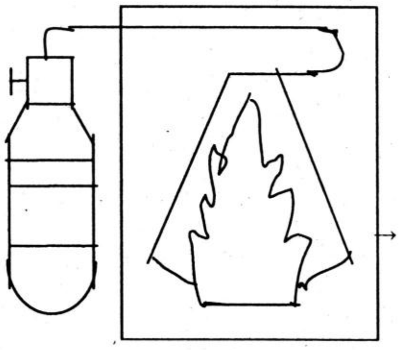


Fig 13. Indirect Release System

Extinguishing agent is then discharged from the cylinder through the diffuser nozzles flooding the area to extinguish the fire quickly. This system is more useful for larger area.

The extinguishing agents tested and used in Fire trace systems include : water, powder, foam, CEA410, FM200, every Halon replacement up to 40 bar working pressure and CO,.

Advantages: This system offers many advantages against conventional fire extinguishing systems as under:

1. Automatic detection and suppression of fire.
2. Extinguishing media is site-specific and minimises damage. It includes water, foam, DCP or clean gas.
3. Flexible, narrow tubing can be inserted into confined spaces.
4. No electricity required. It can work even in electrical failure.
5. Simple design reduces maintenance.
6. Always activates at the hottest point of fire.

7. Quick and simple installation. It can be installed anywhere, even at hard to reach places.
8. Cost effective and practical against other extinguishing systems.
9. Performance unaffected by humidity or air flow.

5.5 Control of Fire and Explosion in Flammable Substances :

Fire or explosion in flammable substance is possible only when it leaks and forms vapour in explosive range. Therefore the first step necessary is to regularly check the tank, container, piping, equipment etc. for leakage and to stop it.

Depending on the vapour density, ventilation should be provided at bottom or upper Jevel to remove accumulation of flammable vapour. If because of heating or cooling, the vapour density is changeable, the ventilation/exhaust system should be designed for operating conditions and not for MSDS value.

Natural ventilation openings can be provided near floor, near ceiling or both. Local exhaust ventilation with explosion-proof .electrical equipment is the best measure.

Un-burnt gases or flammable vapour in combustion chambers of heater, ovens, boilers, furnaces may form an explosive mixture. Therefore in the event of flame failure, proper venting or purging time should be allowed or a timed precognition purge cycle should be followed.

A gas detector can be used to check explosive range in the suspected area.

Gas valves and joints should be frequently checked for leaks. If gas is present, ventilation should be allowed before restarting.

Source of ignition is another contributory factor for fire or explosion. Use of flame/smoke detector, flameproof electric equipment, proper earthing to discharge static electricity, checking of spark or heat generating processes and their control, hot work permit etc. are the remedial measures.

5.6 Fighting Fires of Pesticides :

Pesticides when bum emit toxic fumes and when dissolve in fire water; it cannot be allowed to run anywhere as its contact will become poisonous and birds and animals may die if they drink it. Effect depends upon its toxicity and concentration in air or water. Hazard is also faced by the fire fighters, and the people in vicinity. Therefore utmost care is required while fighting fire of pesticides.

Design of pesticide storage is most important in this regard. Fire detectors and automatic sprinklers should work avoiding human need. Water inside must flow on well designed slope to go to retention basin and from there to the specific collection pond or tank to collect polluted water. Such pond/tank should have proper fencing to keep away people and animals. After the control of fire, this contaminated water must be treated for safe discharge.

If fire takes place in open, persons fighting fire should wear self breathing apparatus, should not face the wind direction, feet, hands and body should be protected, water should be safely diverted to a safe place and covered by sand, lime or any inactivating media.

In case of solvent based liquid pesticide, foam and DCP may be more useful.

Other precautions include prohibition of smoking, keeping flammable pesticide away from sun, heat and source of ignition, keeping people away from risk, calling help if needed and cleaning up area and clothing after extinguishing the fire. Medical attention and treatment without loss of time are necessary if any person is adversely affected.

5.7 Electrical Fires:

Water cannot be used to extinguish electrical fire till it is energised i.e. the circuit is live. If it is possible to put off electrical power supply and to de-energise the electrical circuit, equipment or wire caught in fire, it must be done first. Then this fire can be extinguished as class-A or B fire as stated in Table 13.4 Then water or soda acid type, foam or DCP type and CO or Halon type, any extinguisher can be used.

If it is not possible to put off electricity (de energising not possible), it should be treated as class-E fire and Carbon dioxide or DCP type extinguishers should be used. Sand buckets are also useful.

For a room or enclosure covering electric motors, cables, equipments etc, automatic fire detection and CO injection system are available. In electric power plants such systems are more useful to fight electric fires and to save costly machinery.

Rule 66-A (13) (4) of GFR prescribes following statutory provisions where electrical fires are anticipated

1. Where electrical transformers, switchgears motors and/or electrical apparatus are contained in a room, at least two DCP or CO extinguishers (cap = 2kg) shall be provided within 15m distance from that room.
2. In other rooms where motors and/or other electrical machinery are there, at least one DCP or CO, extinguisher (cap = 5 kg) will be provided within 15 m. distance from such room.
3. Where electric motors are installed on platform, one DCP or co, extinguisher (cap = 2 kg) shall be provided for 3 motors on or below the platform.

This is in adding to the general requirements stated in the rule (66-A).

Thus fighting of electrical fires requires special precaution and provision as stated above. .

5.8 Effects of Combustion Products :

As stated in part 1.3.2 earlier, due to incomplete or complete combustion, following gases are produced and their effects should be controlled as under –

Combustion products (effects) due to fire		Control measures required
1	Free radicals to maintain chain reaction.	DCP or Helogen content extinguishers.
2	Smoke due to incomplete combustion	Make the combustion complete. Supply more air. Remove blockage from air path. Provide smoke escape windows or passage.
3	Heat due to exothermic reaction	Water curtain or shield for protection from radiant heat.
4	Water vapour	Allow to escape safely.
5	CO	Proper respirator for this toxic gas. Increase oxidation CO detector with alarm on furnaces
6	CO_2	Allow to escape safely.

7	SO_2	Allow to escape safely. Use tall chimney or flare etc
8	Gases depending on type of burning chemical (e.g. Toxic gases from pesticide burning etc)	Use appropriate respirator or gas mask to fight such fire. See Part 5.5 & 5.6 for specific fires.

Combustion products should be assumed or detected for its safe control.

5.9 Fire Emergency Action Plan and Drill:

Fire emergency action plan should be similar to 'On-Site Emergency Plan' explained in chapter-19. Here type of emergency is a fire or explosion emergency. Key elements of such plan are as under :

1. Assess all possible fire emergencies or the maximum foreseeable loss (MFL) factor. Mark fire/explosion prone areas on the factory plan.
2. Assess resources (men, material, equipment etc.) available in the plant and make a list of them with their locations, contact phones and incharge persons. See fig. 13.9.
3. Assess resources needed from outside and make a list of them with their places of availability, contact persons and phone numbers.
4. Prepare a central control room for co-ordination of emergency time activities.
5. Prepare an organised group of key persons who will act to control the emergency. Site Main Controller, Incident Controller and other responsibilities should be decided. Everybody should be given their role in writing. Table top exercise and rehearsal will be carried out to shape their actions.
6. All communication systems shall be maintained in workable order. New system shell 663e procured if necessary.
7. Double gates (one for entry, one for exit), unobstructed inner roads and proper sign boards shall be displayed.
8. Housekeeping shall be regularly checked. Accumulation of rubbish and combustibles shall be removed soon.
9. Fire water, working order of fixed fire installations and placement of charged portable extinguishers shall be regularly checked.
10. Alternate power source shall be kept ready.
11. Runners shall be arranged to act in the event of communication failure.
12. Distinctive garments or cap, band etc. shall be given to emergency controllers.
13. Decide assembly points for safe gathering by other people.
14. Keep arrangement for medical, security and transport in readiness to handle the -emergency.
15. Train fire fighting crew, medical staff and other workers for their emergency time and post emergency time activities.
16. It should be assured before restarting the normal work that fire is fully extinguished, environment is cooled, debris etc. removed, all-clear signal is given and the plant is ready for restart.

Fig. 13.9 Fire Tander & Ambulance van to be used in emergency.

Fig. 13.10 Fire fighting with floating pump.

Assessment of probable scenarios and Drill:

Fig. 13.10 Fire fighting with floating pump.

Flammable materials and their processes must be identified first. Based on these flammable materials, their quantities, storage parameters and flammable processes, probable scenarios should be decided and listed in the fire emergency action plan. In periodical fire drill, different scenarios should be selected at different times from the above list. This will help to

train our plant personnel to fight with all types of fire. Necessary PPE should be used while participating in such drills. Scenario of fighting fire with floating pump can also be a part of drill as shown in fig. 13.10.

Fire control room should be well established. Audio visual indication should be available by fire call bells. Fast communication and public address system should be provided. Trained staff should be available. Necessary documents including lists of telephone numbers and mutual help contact persons should be readily available in the control room. It is desirable to conduct at least one fire drill in one quarter or statutory periodicity should be followed.

6 EXPLOSION PHENOMENA :

Before understanding types or forms of explosion, it is necessary to understand explosion it self, its cause and nature, types of explosives, explosion hazards etc.

6.1 Explosion :

Explosion is the result of rapid combustion with a sudden, violent change of pressure involving the liberation and expansion of a large volume of gas.

Thus release of energy in a rapid and uncontrolled manner gives rise to explosion. The released energy may appear as heat, light, sound or mechanical shock. Combustible dusts or powders, flammable vapours and flammable gases can explode. A combustible material, air and source of ignition (or temperature) are the prerequisites for an explosion.

Thus explosion is a sudden and violent release of energy. Its effect depends on the rate at which the energy is released.

Difference between fire and explosion is the rate of release of energy. in fire it is at high rate and in explosion it is at high rate and sudden release.

Three types of energy can be released : physical, chemical or nuclear. Bursting of tyre, vessel, pipe etc. due to overpressure or brittle fracture and flushing of superheated liquid (thermal energy) are examples of physical energy. Chemical energy is released due to chemical reaction. If may be uniform as in case of a vessel, or it may be propagating as in case of a long pipe. Exothermic or runway reaction, decomposition and polymerisation are also examples of chemical explosion. Nuclear energy release can cause nuclear explosion.

Types of explosion are deflagration and detonation. It is also classified as confined and unconfined explosion, BLEVE, gas and dust explosion. See Part 6.2.

Explosion Data refers information on the explosive properties of a material and is usually given in descriptive terms, such as low, moderate or high.

Explosion hazard of a material can be described by its:

1. Sensitivity to mechanical shock or impact, which indicates whether or not the material will burn or explode on shock or friction and
2. Sensitivity to static discharge, which indicates how readily the material can be ignited by an electric shock.

Explosion hazards in process plants are of many types. They include (1) Dust explosions (2) Molten Metal water explosions (e.g. induction furnace) (3) Air system explosions (4) Superheated liquid explosions (5) Mist and Spray explosions and (6) Crankcase explosions.

Explosive limits specify the concern fraction range of a material in air (percentage volume) which will burn or explode in the presence of an ignition source. Explosive limits of some common chemicals are as under:

Chemical	LEL (%)	UEL (%)
Acetylene	3	82
Benzene	1.4	8
Butadiene	2	11.5
Butane	1.9	8.5
Carbon disulphide	1	44
Hydrogen	4	75
Methane	5	15
Natural gas	3.8	17

For other chemicals see MSDS for such explosive limits.

Explosive material is classified as high, low and initiating as under :

High explosive is a chemical compound usually containing nitrogen that detonates as a result of shock or heat. Examples of high explosives are dynamite, ammonium nitrate slurries sensitised with TNT, acetylides of copper and silver, nitroglycerin, mercury fulminate.

Low explosive deflagrates rather than detonates, such as black powder.

Initiating explosive is an explosive composition used as a component of blasting caps, detonators and primers. They are highly sensitive to flame, heat, impact or friction. Examples are lead azide, silver acetylide, mercury fulminate, diazodinitrophenol, nitrosoguanidme, lead styphnate and pentaerythritol tetrardtrate.

In an explosion caused by a high explosive, the rate of energy release is rapid and the explosion has high shattering power. The shock wave from such explosion has a very short duration time.

Sources of ignition that may cause explosion are (1) Sparks (2) Flames and hot surfaces (3) Static electricity (4) Compression and (5) Chemicals-pyrophoric material, unstable compounds, reactive compounds arid catalysts.

Effects of explosion are more relevant to safety problems. They include (1) Blast damage-primary and secondary (2) Missile damage (3) Thermal effects (4) Ground shock (5) Crater and (6) Effects on people.

Shock wave is a pressure wave moving through a gas. A shock wave in open air and combined with wind wave is called 'blast wave'.

Shock-waves due to explosion can cause damage to buildings breaking windows and ejecting missiles over distances of several hundred metres. People can be blown over or knocked down, buried under collapsed material or injured by flying fragments. People in the vicinity of over-pressure may die and injuries due to indirect effects are also serious.

The effects of explosion depend on nature and quantity of material involved and the degree of confinement of the vapour cloud. The pressure decreases rapidly with increase in distance. For example the explosion of a tank containing 50 tonnes of propane results in a pressure of 14 kPa at 250 mt and a pressure of 5 kPa at 500 mt from the tank.

At a pressure of 5 to 10 kPa, people can be injured, while structural demolition and doors/ windows breaking is possible at a pressure of 3 to 10 kPa.

Data on fatality is given by Glasstone as under :

Probability of fatality (%)	**Peak overpressure (psi)* (Duration 400 milliseconds)**
1	35-45
50	45-55
99	55-65

*** Overpressure** = above the atmospheric pressure.

Explosion pressure on an object is as a result of an impacting shock wave.

Much higher overpressures are required to effect the same levels of fatality for the durations of the order of 1-15 milliseconds typical of high explosives.

Data on eardrum rupture due to direct blast effect is given by Eisenberg as under:

Probability of eardrum rupture (%)	Peak overpressure (psi)
1 (threshold)	2.4
10	2.8
50	6.3
90	12.2

Extent of injury (laceration, wound etc.) depends on the weight of a flying fragment (g), its density (g/ CM2), peak pressure (psi)and impact velocity (m/s). Based on these factors, Eisenberg considered a flying glass fragment of lOg .with 2.65 g/cm' density and gave following data :

Type of injury	Peack pressure (psi)	Impact velocity (m/s)
Skin laceration threshold	1-2	15
Serious wound threshold	2-3	30
Serious wound 50% probability	4-5	55
Serious wound 100% probability	7-8	90

Table 13.9 gives some historical figures on explosion events.

Table 13.9 Examples of explosion events.

Year	Place	Chemical	Deaths	Injuries
1921	Oppau, Germany	Ammonium nitrate	430	-
1942	Tessenderloo, Belgium	Ammonium nitrate	100	-
1947	Texas City, US	Ammonium nitrate	552	3000
1948	Ludwigsha fen, W. Germany	Dimethylether	245	3800
1954	Bitburg, Germany	Kerosene	32	16
1967	Lake Charles	Isobutene	7	13
1972	East St. Louis, Illinois, US	Propylene	-	230
1974	Decatur, Illinois, US	Propane	7	152
1974	Flixboroug h, UK	Cyclohexane	28	89
1975	Beak, Netherlands	Propylene	14	107

See also Table 13.1 for fire and explosion events.

Explosion Control Devices :

Main methods to prevent any type of explosion are (1) Avoidance of flammable mixture by good ventilation, dilution, dust collection system, wet methods etc. (2) Avoidance of sources of ignition by avoiding excessive heating (temperature), elimination of spark, flame etc., using spark/flame arrester, using explosion proof electrical equipment and fittings and by avoidance of static electricity, avoiding friction etc.

Explosion Protection and Relief includes the methods of (1) Flame arresters and avoidance of source of ignition. (2) Automatic isolation (3) Automatic suppression (4) Separation (5) Containment (6) Venting of ducts and pipes (7) Venting uF vessels (8) Venting of reactors and (9) Explosion relief of plant and equipment.

Despite all such methods, if explosion is possible, control measures should be adopted such as to limit the spread and effects of an explosion by providing explosion relief devices such as rupture diaphragms or explosion doors/windows, panels or vents, providing blast-walls or strong enclosure etc.

Explosion venting devices:

Explosion venting is the most widely accepted and utilised explosion protection strategy in use today. Various types of devices are used to provide explosion overpressure protection, such as certified rupture panels (explosion vents), hinged devices, shear type fasteners, home made (uncertified) venting panels, "blow out panels" etc. Many of these devices offer some redeeming benefits, but in the end are not reliable as explosion protection options.

In view of the reduced efficiency, hinged enclosures and light-weight rupture diaphragms are recommended.

For explosion venting device, there are five important performance characteristics to consider:

1. Venting Efficiency - Efficient devices require less relief area and/or provide lower vented pressures.
2. Certified Burst Pressure (P) -The venting device tested and warranted to open at the identified pressure every time.
3. Opening Pattern - It provides the expected relief area every time.
4. Fragmentation - Its operation creates dangerous projectiles, therefore less proffered.
5. Reliability - It operates properly when needed.

6.2 Types of Explosion

6.2.1 Dust Explosion

It is possible due to flammable dusts of wood, coal, food(starch, flour, sugar, cocoa, feed stuffs), chemicals, plastics (urea formaldehyde, resin, polyethylene, polystyrene), metals(aluminium, magnesium) etc..

It results from rapid combustion of fine solid particles like iron, aluminium, wood, starch etc. Many solid particles when reduced to fine powder becomes very flammable and explosive.

At a starch/corn plant at Ceder Rapids, Iowa in 1919, 43 people were killed and at Peking, Illinois in 1924, 42 people were killed due to dust explosion.

At a starch plant at Ahmedabad, 29 workers injured and out of them 20 died due to starch dust explosion on 19-12-1991.

Explosion characteristics of dust suspension are as under:

1. Explosibility classification.
2. Minimum explosible concentration.
3. Minimum ignition temperature.
4. Minimum ignition energy.
5. Maximum permissible oxygen concentration to prevent ignition.
6. Explosion pressure characteristics.
   (a) maximum explosion pressure.
   (b) maximum rate of pressure rise.

(c) average rate of pressure rise.

Sources of ignition for dust explosions are (1) Flames, heat or hot surfaces (2) Welding and cutting (3) Mechanical sparks (4) Self-heating (5) Static electricity and (6) Electrical equipment.

Preventive methods for dust explosion include (1) Avoidance of dust suspensions (2) Wet process (3) Elimination of source of ignition and (4) Inserting.

Methods of protection against dust explosion include (1) Isolation (2) Containment (3) Explosion suppression and (4) Explosion venting.

Dust fires can occur in dust deposits and are of two types - flaming and smouldering fires.

6.2.2 Deflagration:

It is an explosion with a resulting shock wave moving at a speed less than the speed of sound in unreacted medium.

Deflagration is vary rapid auto combustion of particles of explosive as a surface phenomenon. It may be initiated by contact of a flame or spark but may be caused by impact or friction. It is a characteristic of low explosives.

Deflagration or detonation is a form of explosion, the former is due to low burning velocity (flame speed as I m/s) while the later is due to high burning velocity (flame speed as 2000-3000 m/s). A detonation generates high pressure and is more destructive than a deflagration. The peak pressure caused by a deflagration in a closed vessel can reach up to 70-80 kPa (8 bar), whereas in case of detonation it easily reaches up to 200 kPa (20 bar).

A deflagration can turn into a detonation while travelling through a long pipe. In that case deflagration velocity exceeds that mentioned above.

6.2.3 Detonation:

It is an explosion with a resulting shock wave' moving at a speed more than the speed of sound in unreacted medium.

Detonation is extremely rapid, self-propagating decomposition of an explosive accompanied by a high pressure-temperature wave that moves at from 10009000 m/sec. It may be initiated by mechanical impact, friction or heat. It is a characteristic of high explosives which varies considerably in their sensitivity to shock, nitro-glycerine being one of the most dangerous in this regard.

Whether a deflagration or detonation takes place depends on the material involved and the conditions under which it occurs. A vapour phase explosion requires some degree of confinement for a detonation to take place.

Detonation of a gas-air mixture is possible directly by a powerful ignition source or by transition from deflagration. Such transition requires a strong acceleration of the flame front. It is possible in pipelines but rarely possible in vessels.

A number of substances are listed which can produce detonation in gas-air mixture. Some corftmonly known substances are :

Acetone	Ethylene
Acetylene	Hydrogen
Benzene	Methane
Chloroform	Methanol
Cyclohexane	Naphthalene
Diethyl ether	Trichloro ethylene

Detonation usually occurs at well below the upper explosive limits. Separate Detonation Limits are available for some substances as under:

Substance	Detonation Limits (%)		Explosive Limits (%)	
	Lower	Upper	LEL	UEL
Acetylene	4.2	50	3	82
Ether	2.8	4.5	1.8	48
Hydrogen	18.3	59	4	75

Though upper detonation limits are normally below upper explosive limits, exceptions have been reported.

6.2.4 Confined and Unconfined Vapour Cloud Explosion (VCE) :

Deflagration and detonation discussed in previous part are confined explosions, as they occur in a process vessel, building or pipe work i.e. in a confined space. The only conditions necessary are that the gas mixture Should be within explosive/detonable range and there should be a source of ignition or the mixture should have been heated to its auto ignition temperature . Transition from deflagration to detonation (mostly in pipeline) is also possible.

An unconfined vapour cloud explosion (UVCE) occurs in open at a distance from the point of vapour release and threatens a larger area. A large release of flammable vapours and cloud formation explodes when spark or friction is available. Though it is a rare possibility but has more potential to damage.

A confined vapour cloud explosion (CVCE) occurs in a confined place (e.g. vessel, pipe, building, pit etc.) while UVCE occurs in an open area. The peak pressures of CVCE are much more higher than that of UVCE.

Some examples of UVCE are as under:

Year	Place	Chemical	Qty. (t)	Deaths
1967	Lake Charles, La.	Isobutane	46	7
1968	Pernis, Netherlands	Hydro Carbon	140	2
1970	Port Hudson, Miss	Propane	29	0
1974	Flixborough, UK	Cyclo-hexane	25	28

Data on equipment involved in UVCE name process equipment, storage tank, transportation vehicle and modes of release as vessel failure, piping, valves or fittings failure, release from venting facilities etc.

Some issues connected with confined and unconfined VCF are as under:

1. Determination of detonation limits.

2. Mass of material released and part vaporised.
3. Possibility from deflagration to detonation.
4. Probability of explosion or fire.
5. Probability and technique of ignition of cloud.
6. Dilution due to air entrainment
7. Distance travelled by cloud before ignition.
8. Nature of flame propagation.
9. Types of effects of explosion.

UVCE due to hydrogen are unusual but did occur. Hydrogen venting should be directly to atmosphere via multiple vents or by a flare.

Methane at normal temperature burn but do not explode. Vapour cloud of LNG might explode.

6.2.5 BLEVE :

Boiling liquid expanding vapour explosion (BLEVE), also referred as a fireball, is a combination of fire and explosion with an intense radiant heat emission within a relatively short time interval.

When a tank or pressure vessel containing liquid or liquefied gas above its boiling point (so heated) fails or ruptures, the contents release as a turbulent mixture of liquid and gas, expanding rapidly and dispersing in air as a cloud. When this cloud is ignited, a fireball occurs causing enormous heat radiation intensity within a few seconds. This heat is sufficient to cause severe skin burns and deaths within a few hundred metres depending on the mass of the gas involved. A BLEVE involving a 50- tonne propane tank can cause "third-degree burn at @ 200 mt and blisters at @ 400 mt

Road/rail accident to a tank car/wagon or due to weakening of structure by fire or physical impact on a overstressed vessel/tank can cause a BLEVE.

Some reported major BLEVE examples are as under:

Year	Location	Chemical	Death	Injury
1966	Feyzin, France	LPG (Propane)	18	90
1969	Laurel, Miss	LPG	2	-
1970	Cresent City, III	LPG	0	66
1971	Houston, Tex	Vinyl chloride	1	-
1972	New Jersey	Propylene	2	-
1985	Mexico City	LPG	650	2500

For IS on explosion see part 3.2.

7 INSPECTION, MAINTENANCE AND TRAINING FOR FIRE PROTECTION

IS:2190 suggests that routine maintenance, inspection and testing of all fire extinguishers in respect of their mechanical parts, extinguishing media and expelling means should be carried out by properly trained personnel at frequent intervals but at-least once in a month to make sure that these are in their proper condition and have not been accidentally discharged or lost pressure or suffered damage. Detailed procedure is also mentioned therein.

It is very difficult for a new worker to use any fire extinguisher, to connect a hydrant, to start fire pump, to hold pressurised nozzele, to use fire ladder etc. Training is necessary for handling and operating any fire equipment. Therefore arrangement should be made for regular training and fire drill for all fire fighting staff. Fire Officer should conduct field demonstrations on fire fighting. The training should be for preventive as well as protective techniques. The frequency and nature of training will depend on the size and type of industry. In a refinery or chemical industry it should be more frequent and continuous. Training record should also be maintained.

All fire equipment should be in ready working condition. The defective equipment may prove dangerous in the event of fire. Therefore regular cleaning, lubricating and testing of all fire fighting equipment are most desirable. The defect can be noticed by inspection and testing only. Therefore it should be found beforehand and rectified immediately. Fire pumps - diesel and electrical - should be run everyday for certain time and their performance should be checked and recorded in a log-book. The extinguishers should be recharged as required. Hydrants, monitors, hose reels, nozzles, couplings, foam making equipment etc. should be regularly inspected, tested under pressure and kept in good repair and working condition.

A small inspection checklist is given here which can be expanded as per own requirement.

A Small Checklist for Fire Prevention

Heat and flame: No smoking areas clearly indicated. Ashes kept in metal containers. Gas connections closed when not in use. No gas leaks. Hot pipe clear of combustible materials.

Housekeeping: Premises free of combustible materials. Metal containers for oily rags. Safe. storage of flammable. No leaks and drippings of flammable. No accumulations of rubbish. Passageways clear of obstacles. Necessary fire awarness signs and posters are shown in Fig. 13.11.

Electrical Equipment : No bare wiring or badly worn insulation. Ground connections clean and tight. Fuse and control boxes clean and closed. Motors and tools free of dirt and grease. Explosion proof fittings for flammable areas. No poor joint. No makeshift wiring.

Fire Protection Equipment : In proper place, unobstructed. Clearly marked, in working order.

For fire safety in chemical, textile and engineering industries, read respective chapters.

See Table 13.8 for periodical testing and maintenance chart.

Fig. 13.11 Fire awarness signs and posters.

8 WORKED EXAMPLES :

Fire load calculation:

For the purpose of solving examples, following information needs to be understood.

An important factor in establishing the basis for the assessment of the fire risk pertaining to any building is the concept of 'fire load' which indicates the quantity of heat liberated per unit area when a - building and its contents are completely burnt.

All occupancies/buildings, etc. can be graded according to their fire hazard and are to be provided for with suitable fire precautions on the basis of the fire load.

Hence, grading of buildings according to both, fire load and fire resistance, can be made.

The formula for calculating fire load is as under:

Fire load

$$= \frac{\text{(combustibles in kg) x calorific value in kcal/kg}}{\text{Floor area in square meters}}$$

Fire grading of the structures:

Structural elements of buildings are graded according to the time factor which is nearly equal to but does not exceed the test period which the element fulfills its specified requirements.

Accordingly, all structural elements have been graded under the following five categories depending upon their fire resistance, viz.,

Grade 1......... 6 hours
Grade 2......... 4 hours
Grade 3......... 2 hours
Grade 4......... 1 hours
Grade 5......... 0.5 hours

Occupancies of High fire load:

Godowns, warehouses, etc. This category as per I.S. specifications exceeds the fire load by 550,000 kcal/sq.mtr, but does not exceed an average of 1,100,000 kcal/sq.mtr of floor area. A fire resistance of 4 hours for these types of occupancies is considered sufficient.

(For reference, the maximum for this type in F.P.S. system is 4,00,000 B.Th.U/sq.ft exceeding an average of 2,00,000 B.Th.U/sq.ft).

Occupancies of Moderate fire load:

Retail shops, bazaars, stalls, factories, etc. Here the fire load exceeds 2,75,000 kcal/sq.mtr, and is up to 550,000 kcal/sq.mtr. Occupancies of this type should have a fire resistance of two hours.

Occupancies of Low fire load:

Ordinary buildings for residential purposes, hotels, offices, schools, etc, or occupancies having a fire load not exceeding 2,75,000 kcal/sq.mtr of net floor area of any compartment, nor exceeding an average of 550,000 kcal/sq.mtr on a limited isolated area. (for reference, the maximum for this type in F.P.S. system is 1,00,000 B.Th.U/sq.ft)

The fire resistance required by buildings of this category to withstand the complete burn-out of their. contents without collapse is I hour as has been found after tests. Extensive investigations carried out in Switzerland and Germany have shown that the fire load in offices varies from 10 kg to 30 kg/sq.mtr wood equivalent to 43,356 to 130,068 kcal/sq.mtr. This type of occupancy has an one hour rating with maximum fire loading up to 60 kg/sq.m. equivalent to 270,978 kcal/sq.mtr

Example-1:

A manufacturing process industry uses the following material. Calculate the Fire load by using the following data: -

Material	Quantity in Kg.	Area in Sq. mtr.	Calorific value	
			(kJ/kg)	(Kcal/kg)
Paper	100	100	15600	3725.28
Wood	2000	300	17500	4179
Coal	10000	500	20000	4776
Rubber	500	200	40000	9552
Petroleum product	5000	400	43000	10268.4

1 K Joul = 0.2388 K. Cal

Fire load

$$= \frac{\text{(Combustibles in kg) x Calorific value in kcal/kg}}{\text{Floor area in square meters}}$$

Fire load (paper) = $\frac{100 \times 3725}{100}$ = 3725 kcal/sq.mt

Fire load (wood) = $\frac{2000 \times 4179}{300}$ = 27860 kcal/sq.mt

Fire load (coal) = $\frac{10000 \times 4776}{500}$ = 95520 kcal/sq.mt

Fire load (rubber) = $\frac{500 \times 9552}{200}$ = 23880 kcal/sq.mt

Fire load (petroleum products)
= $\frac{5000 \times 10268}{400}$ = 128350 kcal/sq.mt

Total fire load = 279335 kcal/sq.mt

As this is less than 550000 kcal/sq.mt, as stated above, it indicates low fire load and requires fire resistance of 1 hour.

Installation of fire extinguishers:

Example-2:

Determine the number of fire extinguishers required to give adequate protection for a given property. Risk: Light engineering workshop (Light hazard)

Area: 315m x 112 m.
Type of hazard: Class 'A' fire due to normal combustibles.

As per IS 2190 this is Light hazard. Therefore one 9 ltr. water expelling extinguisher for every 600 sq.mtr of floor area is required.

Extinguisher should be available within 25 mtr. radius..

Here total area = 315m x 112 m. = 35,280 sq. mtr.

No. of extinguishers= $\frac{35,280 \text{ sq.mt}}{600 \text{ sq.mt}}$ = 58.8 = 59

Example-3:

Determine the number of fire extinguishers required to give adequate protection for a given property. Risk: Petroleum processing unit (High hazard) Area: 300m x 150 m. i.e. 45000 sq. mtr. Type of hazard: Class 'B' fire due to petroleum products.

As per IS 2190 this is High hazard. Therefore two 9 ltr foam chemical/mechanical type; or 5 kg capacity dry powder extinguisher for every 600 sq.mtr with minimum of four extinguishers per compartment is required.

Extinguisher should be available within 15 mtr radius.

Here total area is 45000 sq.mt.

Therefore No. of extinguisher = $\frac{45000 \text{ sq.mt .}}{600 \text{ sq.mt}}$ = 75

E X E R C I S E

1. Explain, State, Mention or Discuss :
   1. The common causes of industrial fire
   2. The following terms :
      (1) Flash point OR Fire point (2) Auto ignition temperature (3) Fire (4) Fuel (5) Fire resisting wall (6) Material Factor (7) Explosion data (8) Explosion hazard (9) Explosive limits (10) Initiating explosive (11) Deluge valve (12) Spray nozzle (13) Insulated equipment (14) Fire barrier (15) Inert gas system.
   3. The sources of explosion OR Types of explosion hazards.
   4. Dust explosion, its characteristics and methods to prevent it.
   5. The methods of explosion protection and relief.
   6. Deflagration and Detonation OR VCE and BLEVE.
   7. Classification of Fire and Extinguishers.
   8. Safety provisions mentioned regarding Tire Exits' OR 'Electrical Fire' in Rule 66 A of the GFR.
   9. Classification of fire safety system.
   10. General control measures for fire.
   11. Different fire prevention activities.
   12. Fire Detection and Alarm systems.
   13. Methods of fire suppression system.
   14. Any two types of portable fire extinguishers, their method of working and how to use them.
   15. Different types of 'Fixed Fire Installations'.
   16. TAC guidelines for water hydrants OR TAC guidelines for water spray system.
   17. Methods to control fire and explosion in flammable substances.
   18. Hazards and precautions while fighting fire of pesticides.
   19. Effects of combustion products and control measures for them.
   20. Which type of fire extinguisher or system you would use to control fire at following places OR State to which class of fire each one of following belongs?

(1) Electrical switch board (2) Computer room (3) Paper mill (4) Electrical cables or electric substation (5) Oleum tank (6) Benzene tank (7) Saw mill (8) Rubber mill (9) Textile industry (10) Vegetable oil storage (II) Tins of oil & grease (12) Paint or varnish containers (13) CNG bus (14) LPG car (15) Sodium metal burning (16) Aluminium cabin (17) Ammonia spheres (18) Tank of sulphuric acid (19) Pesticide go-down (20) Diamond factory

21. Actions which reduce probability officers in industry.
22. Various types of fire prevention and protection system required in a chemical plant handling flammable materials.
23. Advantages and limitations of different types of portable fire extinguishers.
24. What is a water sprinkler system and how does it help in fire fighting?

2. Write Short Notes on :

1. Nature of fire.
2. Factors OR Causes of fire.
3. Flame proof enclosure.
4. Spontaneous ignition.
5. Fire pyramid or Triangle.
6. Fire load.
7. Effects of explosion.
8. Explosion venting devices.
9. Dimensions prescribed in Rule 66A, GFR regarding Tire Exits'.
10. First aid fire fighting arrangement.
11. NFPA code.
12. Fire resistance of building materials.
13. Lightening protection of buildings.
14. Principles of fire prevention and reduction.
15. Hot work permit.
16. Fire retardant treatments.
17. Foam Extinguisher OR DCP Extinguisher.
18. Halon gas Extinguisher.
19. Electrical fires.
20. Fire emergency action plan.
21. Different classes of fire extinguishing media.
22. Types of foam used to extinguish fires.

3. Explain the Difference between :

1. Detonation and Explosion.
2. Detonation and Deflagration.
3. Flash point and Fire point.
4. Flash back and Flash fire.
5. Smoke vents and Venting fire.
6. VCE & BLEVE OR CVCE & UVCE.
7. Class A fires arid Class E fires.
8. High and low explosive.
9. Types of explosion and Effects of explosion.
10. Fire stopping and Fire check zones.
11. Fire prevention and Fire protection.
12. Fire fighting and Salvage.
13. Soda acid extinguisher and CO_2 extinguisher.
14. DCP extinguisher and Foam extinguisher.
15. Automatic Fire Detection and Extinguishing system.

4. **Comment on following explaining whether it is true or not:**
   1. Many examples of fire have been reported where many people died and many injured.
   2. Causes of fire are not many. One or two causes play role in starting fire.
   3. There is no need to classify fire. All fires are fire. They can be extinguished by water.
   4. Regular maintenance of fire fighting equipment is most important.

Reference and Recommended Reading

1. Accident Prevention Manual for Industrial Operations, National safety Council, Chicago, Illinois.
2. Occupational Health and Safety in Manufacturing Industries, M.K. Poltev, Mir Publishers, Moscow.
3. BSI Handbook, New Delhi and various Indian Standards stated in this Chapter.
4. NFPA Fire Protection Manual (16 volumes), USA.
5. Fire Protection Manual, Factory Manual Systems, HMSO, London.
6. Fire Protection Guide on Hazardous Materials, National Fire Protection, USA.
7. A handbook of Fire Technology, R.S. Gupta, Orient Longman Ltd., Mumbai.
8. Dust Explosions and Fires, K.N. Palmar, Chapman and Hall, London.
9. Fuel and Combustion, Sharma, Tata McGrawHill, Delhi.
10. Smoke Control in Fire Safety Design, Butcher and Parnell, E & FN Spon Ltd., London.
11. Booklet on Rules governing fire protection systems. The Oriental Insurance Co'. Ltd., Orient House, Tata Road, Bombay -400020.
12. Fire Protection Manual (Part I and n), Regional committees of the Tariff Advisory Committee, Bombay.
13. Rules for Segregation, Tariff Advisory Committee, Bombay Regional Committee, Bombay.
14. Rules for Water Spray Systems, Tariff Advisory Committee, Ador House, 1st floor, 6 K, Dubash marg, Bombay - 400023.
15. Regulations for the Electrical equipment of Buildings by Tariff Advisory Committee (General Insurance), Bombay.
16. Loss Prevention in the Process Industries, Frank P. Lees, Butterworths.
17. Major Hazard Control, a practical manual, ILO, Geneva.
18. The Factories Act & Rules.
19. Handbook for Fire calculations and Fire Risk Assessment in the Process Industry by Scand power A/S and Sintef - NBL, Norway.
20. Industrial Fire Protection Handbook. R.Craig Schroll
21. Fundamentals of Fire Protection for the Safety Professional by Lon Ferguson and Christopher Janicak

CHAPTER – 14

Machine Guarding

THEME

1. REQUIREMENTS OF MACHINE GUARDING

Machine guarding is required as a basic need as well as statutory requirement.

1.1 Basic Need and Importance :

Basic need of machine guarding is to protect against contact with the dangerous and moving parts of a machine, work in process and failure due to mechanical, electrical, chemical or human causes. The guards remove workers' fear and thereby increase their morale and the production. They allow the operation at higher speeds and compensate the expenditure on guarding.

Where danger exists from machinery, safe working practice alone is insufficient and cannot, be relied on from safety point of view. Guards are essential as an engineering and built-in control to prevent accident when other precautions fail.

See Table No. 5.6, 5.8, 5.20, 5.21 and 5.23 of Chapter-5 for accidents due to machinery. Absence or defect of guard is the main cause of accidents due to moving machines or their dangerous parts. Types of such dangerous parts are many. See Part 3.3 for their details.

It is obvious that when cutting edges of sharp tools, rotating and projecting parts, point of operation or contact point of die and punch, nip (contact) points of pulley -.belts or gears, rollers, calendar rolls, traversing tools or bed etc. are unguarded and workers are exposed to such openly moving i.e. unguarded parts, their risk of accident is highest. Long sleeves (shirt), sadis, chain, i.e. muffler, shawl etc can trap or entangle into unguarded rotating parts and serious or fatal accidents are possible. Many such accidents have happened also. Therefore, basic need of machine guarding must first be understood.

Mainly machine guarding is of two types: (1) Guarding for points of operation i.e. guarding for cutting edges, tool points, press or shear points, nip or running contact points, feed points etc., and (2) Guarding for Power Transmission Machinery i.e. gem's, •pulley-belts, couplings, clutches, brakes, cams, shafts, rolls, rods that transmit energy and motion from the source of power (prime mover) to the point of operation.

1.2 Statutory Requirement:

Besides its basic need, machine guarding is a statutory requirement since a century. With the growth of industrialisation, need of machine guarding was noticed and incorporated by the enactment of the Factories Act in England in 1844 and in India in 1881.

The ILO Convention (No. 119) and Recommendation (No. 118) of 1963, regarding 'Guarding of Machinery' require national laws or regulations to provide guards on dangerous machine parts before sale or purchase of machinery.

The Factories Act of 1881 was amended in 1891, 1911, 1922, 1923, 1926, 1931, 1934, 1948, 1976 and 1987 to gradually include more and more aspects of safety and other provisions. The present Act known as the 'Factories Act 1948' contains Chapter-IV on safety which includes many provisions of machine guarding. The Gujarat Factories Rules 1963 provides further details to supplement these provisions. The whole subject of the Factories Act and Rules is separately dealt with in Chapter-27, but, some relevant portion is give below:

Definitions : The Factories Act defines as under:

Power means electrical energy or any other form of energy which is mechanically transmitted and is not generated by human or animal agency.

Prime mover means any engine, motor or other appliance which generates or otherwise provides power.

Transmission machinery means any shaft, wheel, drum, pulley, system of pulleys, coupling, clutch, driving belt or other appliance or device by which the motion of a prime mover is transmitted to or received by any machinery or appliance.

Machinery includes prime movers, transmission machinery and all other appliances whereby power is generated, transformed, transmitted or applied. Belt includes any driving strap or rope.

Maintained means maintained in an efficient state, in efficient working order and in good repair.

Fencing of Machinery : Section-21 requires that every moving part of a prime mover, flywheel, headrace and tailrace of water wheel and turbine, lathe, electric generator, motor, rotary converter, transmission machinery and every dangerous part of any other machinery shall be securely constructed, positioned or fenced by safeguards of substantial construction and constantly maintained and kept in position while the parts of machinery they are fencing are in motion or in use.

Work on or near machinery in motion: Section22 requires that any examination, lubrication, adjusting operation, mounting or shifting of belts while the machinery is in motion shall be carried "out by a specially trained adult male worker wearing tight fitting clothing supplied by the occupier and his name shall be recorded in the register in Form No. 8. Such worker shall not handle a belt at a moving pulley unless the belt is not more than 15 cm in width, the pulley is a normal drive (no flywheel or balance wheel), the belt joint is laced or flush with belt, the pulley, joint and pulley rim are in good repair, there is reasonable clearance to work, secure foothold / handhold are provided and any ladder being used is secured fixed or held by a second person. At that time other parts in motion shall be securely fenced to prevent their contact. Woman or young person is not allowed to do such work.

Employment of young persons on dangerous machines : On power presses except hydraulic presses, milling machines, guillotine machines, circular saws and platen printing machines no young person shall work unless he has been fully instructed regarding their dangers and precautions to be observed and has received sufficient training to work on that machine and is under adequate supervision by a person who has a thorough knowledge and experience of that machine (Sec. 23 & Rule 57).

Striking gear and devices for cutting off power: Suitable striking gear or other efficient device to move driving belts to and from fast and loose pulleys and to prevent the belt from creeping back on to the fast pulley, shall be used and maintained. Driving belts not in use should not rest or ride upon shafting in motion (for which belt hangers are necessary). Other devices for cutting off power are necessary in every work room. Such devices shall be so locked to prevent accidental starting of the machinery.

Self acting machines : 45 cm or more clear space is necessary from the end of maximum traverse of any self-acting machine or material carried thereon.

Casing of new machinery : Every set screw, bolt, key, gearing shall be completely encased or guarded to prevent danger.

Work near Cotton-openers : No woman or child shall work in a room where cotton opener is at work. If the feed-end is fully partitioned from the delivery end, their employment on feed-end side is permissible.

Revolving machinery : Effective measures are necessary to ensure not to exceed the safe working peripheral speed of every grinding wheel, revolving vessel, cage, basket, flywheel, pulley, disc or similar appliance driven by power. A notice indicating maximum safe working peripheral speed of the grinding wheel, speed of the shaft or spindle upon which the wheel is mounted and the diameter of the pulley to secure safe working peripheral speed of grinding wheel shall be affixed near each such machine. Effective brake is also required.

Further Safety Precautions: Rule 54 prescribes machine guarding details in respect of textile machinery, cotton ginning machinery, wood-working machinery, rubber mills, centrifugal machines, power press and shears, slitters and guillotine machines.

Part 4.4 of this Chapter describes guarding of some such machines.

2 INDIAN STANDARDS

Many Indian Standards are available. A few are given below in Table 14.1:

No.	Subject	IS No.
1	List of IS on Safety, Mechanical Engineering, Foundry Industry, Automobile Industry and Agricultural Equipment Industry.	--
2	Drilling, Safety code	4081
3	Compressors safety	11461
4	Conveyor safety	6687, 7155
5	Printing machinery safety	12619
6	Unfired pressure vessel	2825
7	Belting for power transmission (part I for Flat belt, Part II for	2122

	Vee-belt)	
8	Care and practice of abrasive wheels	1991
9	Degrees of protection provided by enclosure for rotating electrical machinery	4691
10	Wood working machines (Part 1 to 24)	8964
11	Mechanical Guarding of Machinery	9474
12	Mechanical Press	7468, 7469, 10644
13	Machine – shaft heights	2031
14	Machine – metal forming terminology	6652
15	Machine – working level height	7229
16	Machine tools – safety requirements	11016

These standards are useful from design to maintenance purposes..

3 PRINCIPLES OF MACHINE GUARDING

3.1 Definitions :

1. **Point of operation:** That area on a machine where material is positioned for processing by 'the machine and where work is actually being performed on the material.

2. **Zero Mechanical State (ZMS):** The mechanical state of a machine in which every power source that can produce a machine .member movement has been shut/locked off. This means deenergised, de-pressurised and neutralized condition of the machine or equipment which provides maximum protection against unexpected mechanical movement.

3. **Power off:** The state in which power (electric, pneumatic, hydraulic, atomic etc.) cannot flow to the machine is considered a power-off stage.

4. **Power-locked off:** The state in which the device that turns power off is locked in the off position with the padlock of every individual who is working on the machine.

5. **Guarding:** Any means of effectively preventing personnel from coming in contact with the moving parts of machinery or equipment which could cause physical harm to the personnel. In case of a power-press, a cover on point of operation (die and punch) is called 'guard' while those on other danger zones are called 'enclosure' or 'safeguard'.

   Safety by Guarding is most important as other methods are not always possible. Depending upon the dangerous part, its size, position, speed etc., a guard should be selected. Generally the parts to be guarded fall within three categories:

   1. The prime mover.
   2. Transmission parts from the prime mover to the machine and the transmission parts in the machine itself. It is desirable to minimise them and enclose completely.
   3. Operating parts of a machine, of which the points of dangerous operation need effective guarding.

6. **A machine guard** means any enclosure, barrier or device constructed to prevent a person or his clothing coming into contact .with dangerous parts of the machine. The point of operation is that

part of working machine at which cutting, shaping, forming or any other necessary operation is accomplished. A guard for that part is known as the point of operation guard.

7. **Enclosures:** Guarding by fixed physical barriers that are mounted on or around a machine to prevent access to the moving parts.

8. **Fencing:** Guarding by means of a locked fence or rail enclosure which restricts access to the machine except by authorised personnel, Enclosures must be a minimum 1m (42 in) away from the dangerous part of the machine.

9. **Safety by Position or Location:** It is a guarding as a result of the physical inaccessibility of a particular hazard under normal operating conditions or use. Words "Safe by location" or "Safe by position" are used to denote safety by distance.

   The words "safe by position" are used by Section-21 of the Factories Act. It means the situation (out of reach) or position in such a way that normally it is not possible to touch the dangerous parts. However intentional contact should be prevented. Moving feed opening can be made safe by position if gravity or remote feeding device is applied. But, then, it is a type of indirect guarding. A distance of 2.6 m or 8'6" is considered safe by position.

10. **Ingoing (in-running) Nips:** A hazard area created by two or more mechanical components rotating in opposite directions in the' same plane and in close conjunction or interaction e.g. calendar rolls, in running rolls of textile or paper machines.

11. **Safety by Construction :** It indicates parts so constructed as to cause no hazard, viz. shaft, sliding and link mechanism so located or with slow speed that their contact is not dangerous. Built-in-safety- is the similar word for designing and constructing new machinery in such a way to make the dangerous parts safe by deep housing or position etc.

3.2 Elimination of Hazard :

Hazards from machinery are generally of following types:

Crushing, shearing, cutting or severing, entanglement, drawing-in or trapping, impact, stabbing or puncture, friction or abrasion, ejection of material from the machine, contact with moving part, hot surface or sharp edge, free fall of any material, tool or equipment and high pressur-e-fluid ejection.

The basic steps to prevent accidents are :

1. Eliminate the hazard from the machine, method, material, structure etc.
2. Control the hazard by enclosing or guarding it at its source.
3. Train personnel to know that hazard and to follow the safe job method to avoid it and
4. Use personnel protective equipment necessary.

Thus machine guarding is one of the basic step to eliminate hazard. Actually the machine should be so designed and constructed that all safety points are incorporated by built-in safety principle and need of extra guards should be minimum. A machine safety checklist given by the NSC, USA is worth mentioning. It suggests:.

1. Design the machine so that it is impossible for an operator to get at the point of operation or any other hazard point while the machine is working.
2. Design the machine so that corners and edges
3. Locate machine controls so that the operator will not be in "the vicinity of the point of operation while actuating the controls.
4. Place the control so that the operator will not have to reach too far or move his body off balance in order to operate the machine.
5. Build power transmission and drive mechanisms as integral parts of the machine.
6. Build overload devices into the machine.
7. Design the machine for single-point lubrication.
8. Design mechanical, instead of manual holding devices.
9. Design a mechanical device for feeding and ejecting parts so as to eliminate the use of hands for such operations.
10. Minimise motor drift-time.
11. Provide fail-safe interlocks so that the machine cannot be started when it is being loaded or unloaded or being worked on.
12. Provide a grounding system for all electrical equipment.
13. Provide standard access platform and ladders for inspection and maintenance of equipment.
14. Design component parts of equipment for easy and safe removal and replacement to facilitate maintenance.
15. Reduce sources of excessive noise, vibration, heat etc.

Such built-in-care in construction principles of a machine or equipment should also ensure that it will cause no harm to the environment, no discomfort to the operator, no operational contingencies, no contact with overheated or chilled surfaces,, no electrical accident and no access to the danger zone.

See also Part 4.2 for built-in safety devices.

3.3 Groups of Dangerous Parts :

Some examples of dangerous parts of machines are shown in fig. 14.1. They pose hazards and there fore they need appropriate machine guards or fancing.

3.3.1 According to Motions :

Dangerous parts to be guarded according to their motions are generally classified as follows :

Group-1. Rotary Motions : (1) Rotating parts alone viz. shafts, coupling, spindles, projections on moving parts, fly-wheel, saw, gear, knife, cutting tool etc. (2) In-running nips subdivided as (a) Between parts rotating in opposite direction - gears, rolls etc. (b) Between rotating and tangential moving parts conveyors, belt drives, rack and pinion etc. (c) Between rotating and fixed parts - grinding wheel, paper machine felt or roll, drums, cylinders, worms, spirals etc.

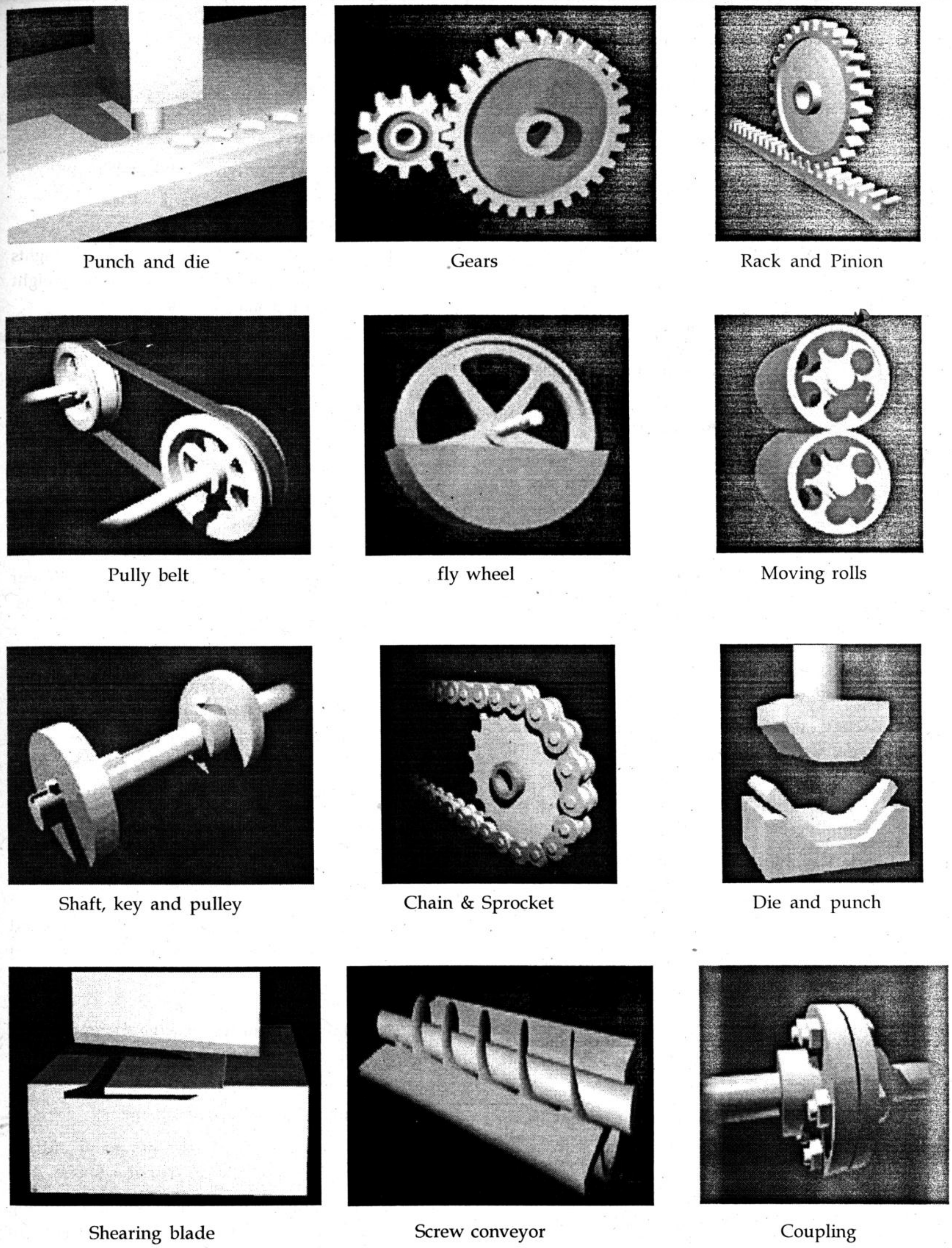


Fig. 14.1 Examples of dangerous parts of machines

Group-2. Reciprocating Sliding Motions : (1) Reciprocating sliding motions and fixed parts (a) Approach type - danger of crushing viz. slides (rams) on power presses and forging hammers, pistons, cross rod of a steam engine and riveting machines (b) Passing types - danger of shearing, viz. planning machine, shaper, spot welder clamping fixtures, guillotine and the shear, power press etc. (2) Single sliding motion- abrasive or sharp nature of objects such as saws or crocodile clips on belts.

Group-3. Rotating/ Sliding Motion : A cam gear having sliding and turning movement etc. falls within this group.

Group-4. Oscillating Motions : Trapping points between two moving parts or between a moving part and a fixed object viz. a pendulum, crankshaft, closing platens etc.

3.3.2 According lo H.A. Hepburn

25 groups of intrinsically dangerous parts of machinery as classified by H.A. Hepburn are as follows:

(a) Single Revolving Units - Risk of entanglement

1. Revolving open arm pulleys and other discontinuous rotating parts - Fan blades, spur gear wheels etc.
2. Revolving worms or spirals in casing Meat mincers, rubber extruders, spiral conveyors.
3. Projections on revolving parts - Key heads, set screws, cotter pins, complying belts etc.
4. Revolving shafts, spindles, mandrels and bars - drills, reamers, boring bar, stock bar, milling etc.

(b) Single Revolving Units - Risk of cutting or abrading

5. Revolving high speed cages in casings Hydro-extractors, centrifuge.
6. Revolving or oscillating mixer .arms in casings - Dough mixture, rubber solution mixture.
7. Revolving drums and cylinders - uncased - Rumbles, shaking barrels, rag digesters etc.
8. Revolving cutting tools - Circular saws, milling cutters, shears, routers, chain mortisers.
9. Abrasive wheels - Grinding wheels etc.

(c) In-running Parts - Risk of nipping and tearing

10. In running nips of the belt and pulley type - Pulley - belt, chain and sprocket gear, conveyor belt etc.
11. Revolving beaters, spiked cylinders and drums - Scutchers, cotton opener, laundry washers.
12. In running nips between pairs of revolving parts - Gear wheels, friction wheels, calendar bowls, mangle rolls etc.
13. Nips between, gears and rack strips. (d) Reciprocating Tools or Parts - Risk of cutting or crushing
14. Moving balance weights and dead weights - Hydraulic accumulators, balance weight on slotting machine etc.
15. Reciprocating knives and saws Guillotines for metal, rubber and paper cutting, trimmers, perforators etc.
16. Nips between reciprocating and fixed parts other than tools and dies - Sliding table and fixture, shaping machine and fixture.
17. Closing nips between platen motions Letter press platen printing machine, power presses.
18. Reciprocating tools and dies - Power presses, drop stamps, relief stamps, bending press, revolution press.
19. Nips between revolving control handles and fixed part - Traverse gear handles of lathes, milling machine etc.

20. Nips between revolving wheels or cylinders in pans or on tables - Sand mixtures, edge runners, crushing mill, mortar mill etc.
21. Nips between fixed parts and unidirectional moving parts - Buckets or hoppers or conveyors against tipping-bars etc.
22. Nips between connecting rods or links and rotating wheels, cranks or disc - Flat bed printing machine, jacquard loom, automatic looms.
23. Pawl and notched wheel devices for intermittent feed motions - Planer tool feed motion, power press dial feed table etc.

(e) Running Edges - Risk of cutting

24. Cutting edges of endless band cutting machines - Band saws, band knives.
25. Projecting belt fasteners and fast running belts - Bolt and nut fasteners, wirp pin fasteners, centrifuge belt etc.

Above discussed motions are shown in figure 147 143 and 144

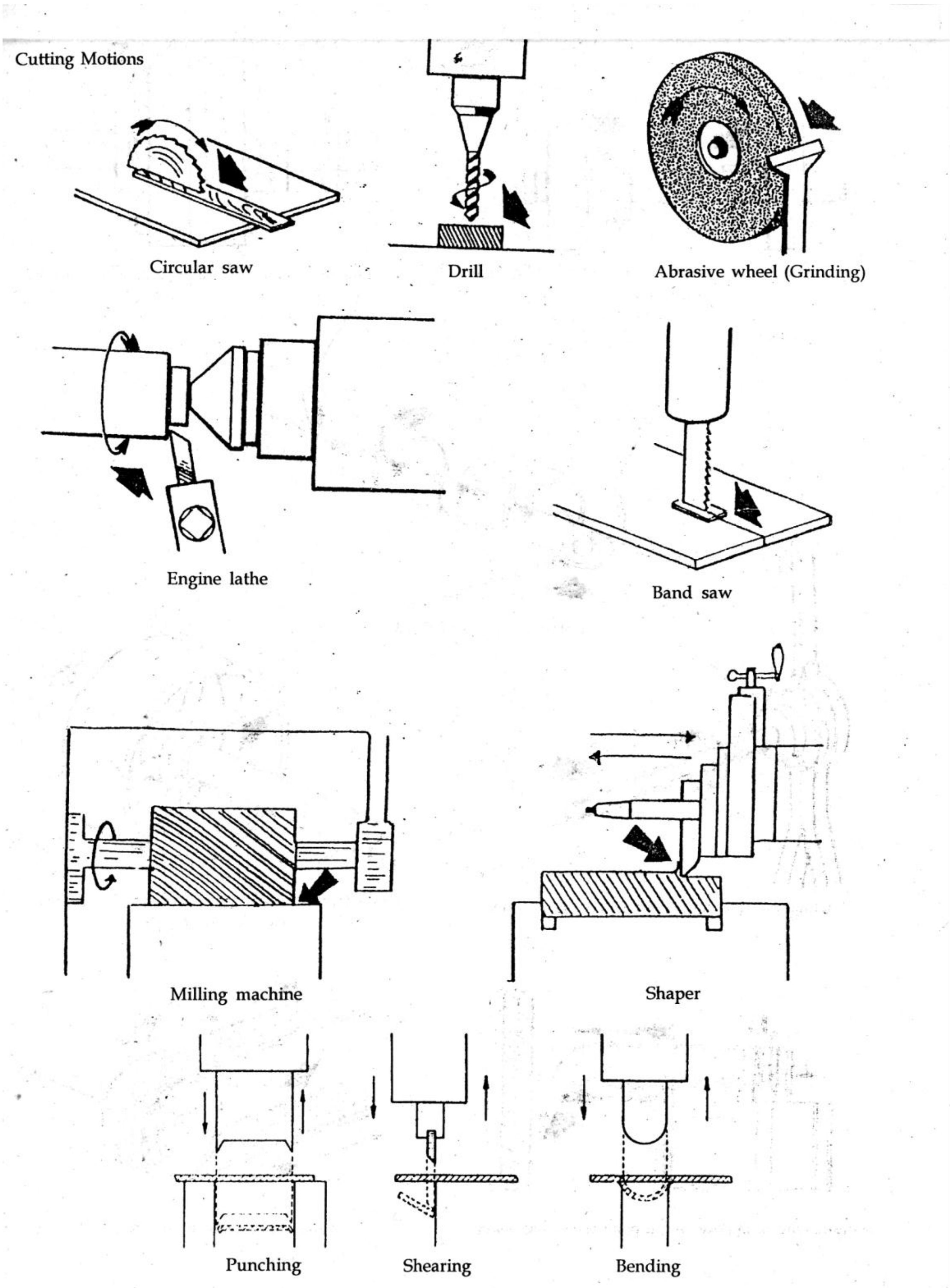
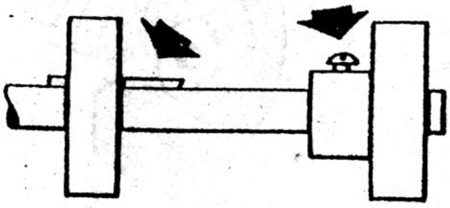
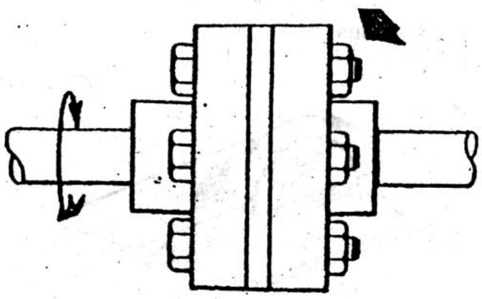


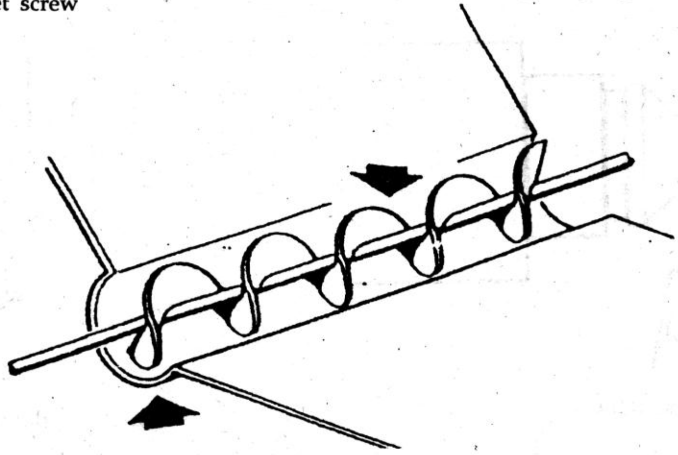
Fig. 14.2 Different types of machine motions (indicating hazards also).



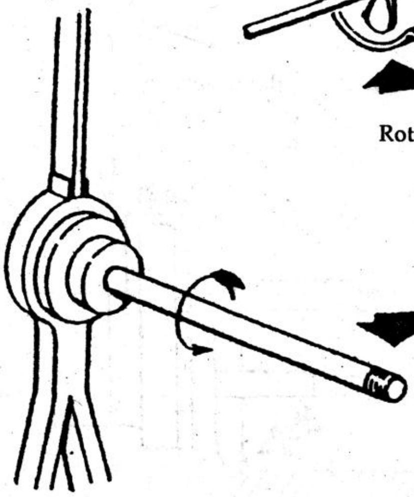
Rotating shaft and pulleys with projecting key and set screw



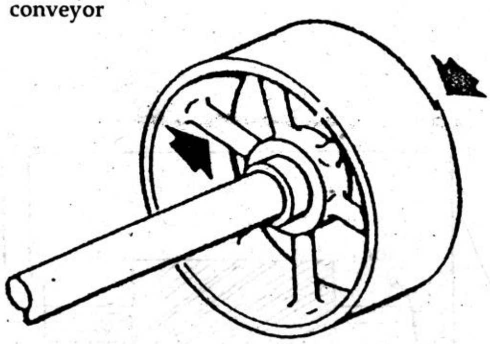
Rotating coupling with projecting bolt heads



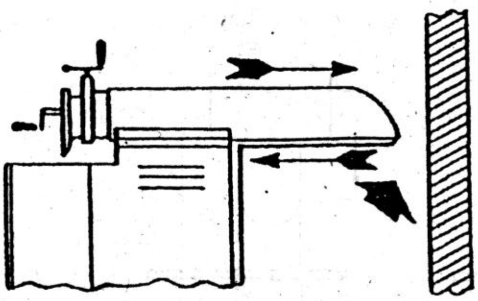
Rotating motion of screw conveyor



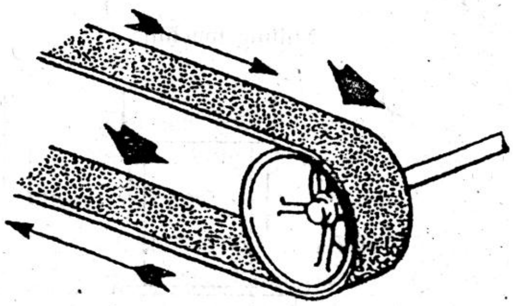
Rotating bar stock at the end of screw machine



Rotating pulley with spokes and projecting burr on face (edge) of pulley



Reciprocating head creats pinch point with fixed object.



Transverse motion of pulley and belt.

Fig. 14.3 Examples of rotating, reciprocating and transversing motions (indicating hazards also).

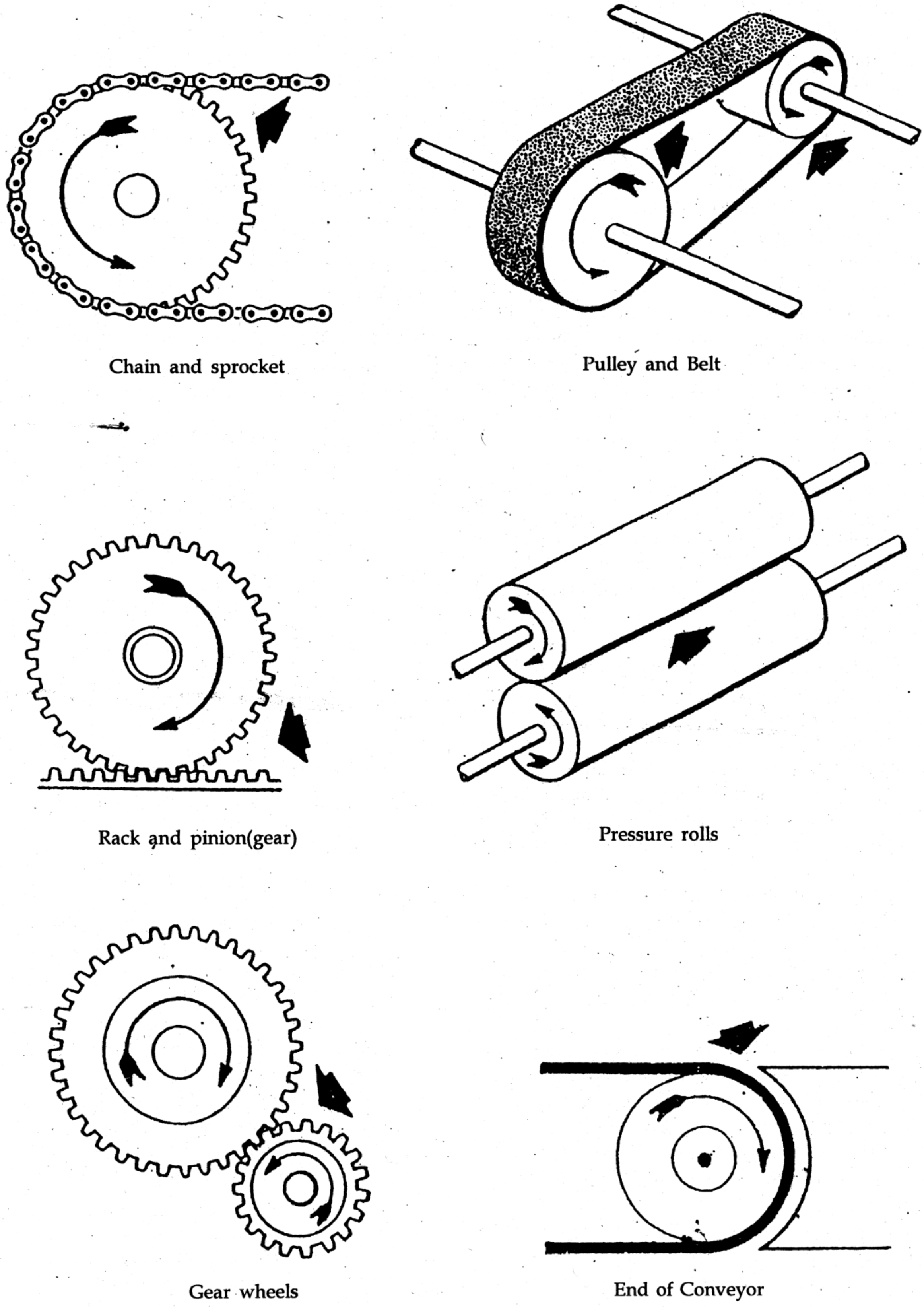


Fig. 14.4 Examples of inrunning nip points(hazards) where nip guards are required.

3.4 Requisite Characteristics (Design principles) of Guards:

Twelve characteristics, design principles, specifications, basic requirements or good guarding practice for machine guarding are:

1. With its primary purpose of protection, it should also facilitate the work i.e. it should be convenient, reliable and not hampering the work or rate of production.
2. It should fully satisfy the legal provisions and IS prescribed i.e. it should conform the standards, be a complete guard and not incomplete or giving any access to the part to be protected. It should be as close as possible.
3. It should be suitable and effective to the job and the machine. It should not weaken the machine.
4. It should allow for oiling, inspection, adjustment and repair. If it requires opening for this purpose, it should be easily and quickly replaceable.
5. It should withstand wear, shock, vibration and long use with minimum maintenance. If it requires frequent opening and closing, this factor becomes more important.
6. It should be of proper material and construction. It should be well fitted. Fire and corrosion resistant material is preferable..
7. It should be free from self-hazard such as sharp or rough edges, nails, splinters, more opening, noise, vibration etc.
8. If visual watch of operation is necessary, it should be transparent and yet durable.
9. If dusting is possible as in case of machining of wood, rubber, brass, cast iron etc., apart from the guard, dust suction device should also be fitted as a special guarding.
10. It should be fail-safe i.e. if it fails or breaks it should stop the machine or at least it should give warning (alarm) to stop the machine.
11. It should be interlocking type i.e. the machine will not start till it is not closed and will stop soon if it is opened.
12. It should fulfil special requirement depending upon its purpose viz. distance guard should provide sufficient protective distance, trip guard must immediately trip the machine etc.

It may be difficult to fulfil all these requirements but it is desirable that safety engineers must design guards by keeping above points in mind. If it is no possible to provide guard without interfering with production, safety should be preceded over production Similarly when complete protection is not possible incomplete (maximum possible) protection, should b(preferred to no protection.

4 TYPES AND GUARDS SELECTION OF

Ways and means for machine safety can be classified as under :

Machine Safety

- Safety by construction
- Safety by position
- Built-in safety
- Safety by machine controls
- Safety by precautions and maintenance
- Safety by Guarding prime mover, transmission parts and points of operation
  - Fixed guards or fencing
    1 Total enclosure
    2 With .limited access
    3 With adjustable access
    4 Distance or barrier guard
  - Interlock guards.
    1 Mechanical interlocking
    2 Electrical interlocking
    3 Tripguard
    4 Control guard
  - Automatic guards
    1 Mechanical type-sweep, knock or push away guard
    2 Photo-electric cell type
  - Safety devices
    1 Two-hand control
    2 Optical sensor
    3 Electro-magnetic sensor
    4 Mechanical feed (conveyor)
    5 Feed tools (tong, magnetic device)
    6 Non repeat device
    7 Pedal guard

Thus machine guarding is one of the ways for machine safety and first two modes of safety b) construction and safety by position are equally important. They are explained below in brief :

Safety by Construction : A shaft end or any par without nip, spoke, nail or protruding projection moving at very slow speed, any sliding or link mechanism moving at very slow speed without danger of trapping or crushing, a power operated sliding door which will stop or return at touch are some of the examples of safety by construction. Such unguarded slow moving parts without risk are considered safe by construction. Because of high production rate and dangerous cutting shaping operations required, this type of slow moving machinery is hardly possible. Even then safe construction of machines must always be aimed at. At least outer or exposed part must be safe.

Built-in-safety should not be understood as safety by construction. The dangerous moving parts enclosed in casing so that no separate guard is required are an example of built-in-safety. Here speed, nip or sharp edge of moving parts are dangerous if the casing is removed, therefore their construction is unsafe and safety is built-in by providing a solid enclosure so that the moving parts are neither visible nor exposed. See Part 4.2 for details.

Safety by Position: When dangerous parts are so situated by height, depth or position that it is normally difficult to touch them, they are called 'safe by position'. Overhead transmission machinery, dangerous parts out of reach because of height or covered by some structure so as to prevent access or contact, are generally called safe by possible.

However this concept does not provide full safety. Unpredictable behaviour of a 'person or. touching because of cleaning by broom stick can still cause an accident. Therefore decision regarding 'safe by position' should be thought twice with all considerations.

Feed openings where access is possible and guard is not possible, should be made safe by providing gravity, conveyor or remote control feeding. This is also a way of safety by position. Hopper depth should be sufficient so that extended arm cannot touch the dangerous part.

4.1 Types of Guards and Selection:

Unguarded dangerous machine parts are shown in Fig. 14.5. They need guards. Various types of guards are shown in fig. 14.6(A) and (B)

Various types of guards are shown classified in previous part. Their suitability should be selected. Preference should be given to the simplest type of guard ensuring complete safety. Some are described below and some in subsequent paras.

Fixed guards : They are simple, easy to provide and cover parts as well as throwing particles if any. They are of various types, materials and design. A minimum thickness of 1.2 mm is recommended for sheet metal. Guard opening and its distance from the dangerous part should be fully safe. Such spacing and distance are prescribed and formulae are also available, but it is rather a matter of fact of individual requirement. They should be close fit, robust and should withstand speed, vibration, impact etc. They should be properly fitted by clamps, bolts etc. They require special tool for their removal.

Every fixed guard (or other guard) on point of operation should prevent entry of fingers (preferably the smallest finger) or hands by reaching over, under, or around the guard into the point of operation. Its fasteners should not be easily openable to prevent misuse or accident. On point of operation it should offer full visibility, while on transmission parts it may not.

Following formula was suggested by the Chief Inspector of Factories, UK in his Report of 1975 –

$$Y = \frac{X}{12} + 6$$

where Y = guard opening or gap in mm and
X = distance from danger in mm

Fixed total enclosures are used to cover prime mover and transmission parts such as headstock gearing, belts, pulleys etc.

Fixed limited access guards provide minimum opening in the guard to insert and remove the job (material). It disallows finger to trap. If the material is jammed, it requires special tool and opening and refitting of the guard. They are used on power presses..

Fixed adjustable access guards -provide opening through or around guard to accommodate materials of different sizes. Guards on band saws, jigsaws, milling cutter etc. can be raised or lowered as per the thickness to cut. Such guard known as "crown guard" on circular saw or drill tool adjusts automatically as the job or tool moves. Its disadvantage is that it gives little protection when thin material is processed. See Fig. 14.6(B)

Fencing, distance or barrier guards make it physically difficult for people to gain access. Nip guard to in-running rolls and fixed railing or fencing to engines, motors, planning or shaping machine are of this type.

Interlock guards make certain that the machine cannot be started until the guard screen is in close position and conversely the guard cannot be removed until the working parts have been stopped. Mechanical, electrical, hydraulic or pneumatic systems are used to actuate the guard. Mechanical interlocking of a power press, card machine and electrical (limit or micro switches) interlocking of headstock covers of many textile machinery are such examples. Many times the interlocking is by-passed or made ineffective which is not good. This is its disadvantage. Correct working condition of limit switch is most important. Limit or micro switches are used but they are not fully safe.

Trip guards are actuated by anyone approaching beyond the safe position and operate a stop or reverse control viz. trip rod along the conveyor belt, hand trip on a rubber mill, electronic eye, lift door, platen printing guard, calendars or dough brakes etc.

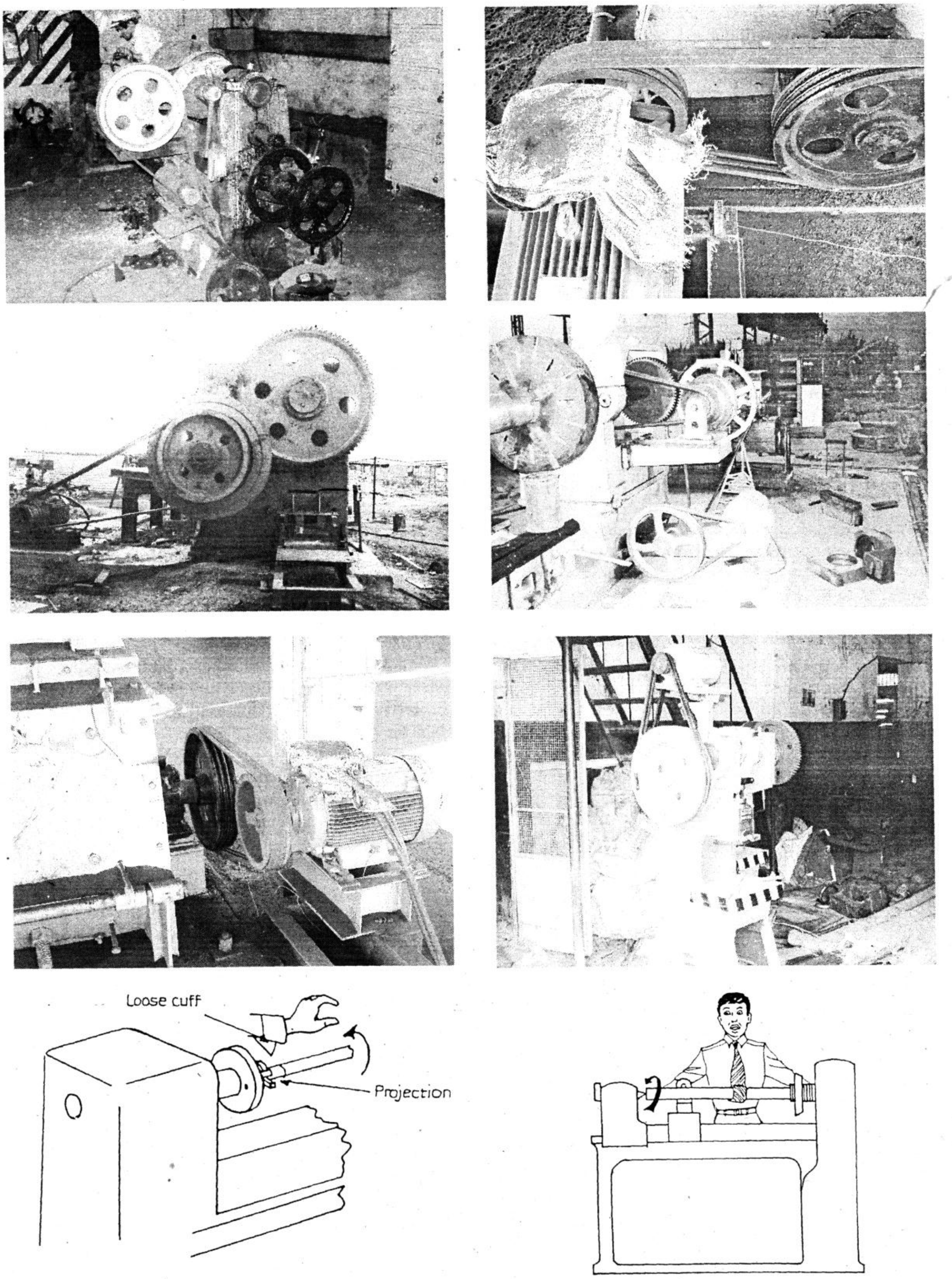


Fig. 14.5 Examples of unguarded dagerous machine parts (hazards). They need guards.

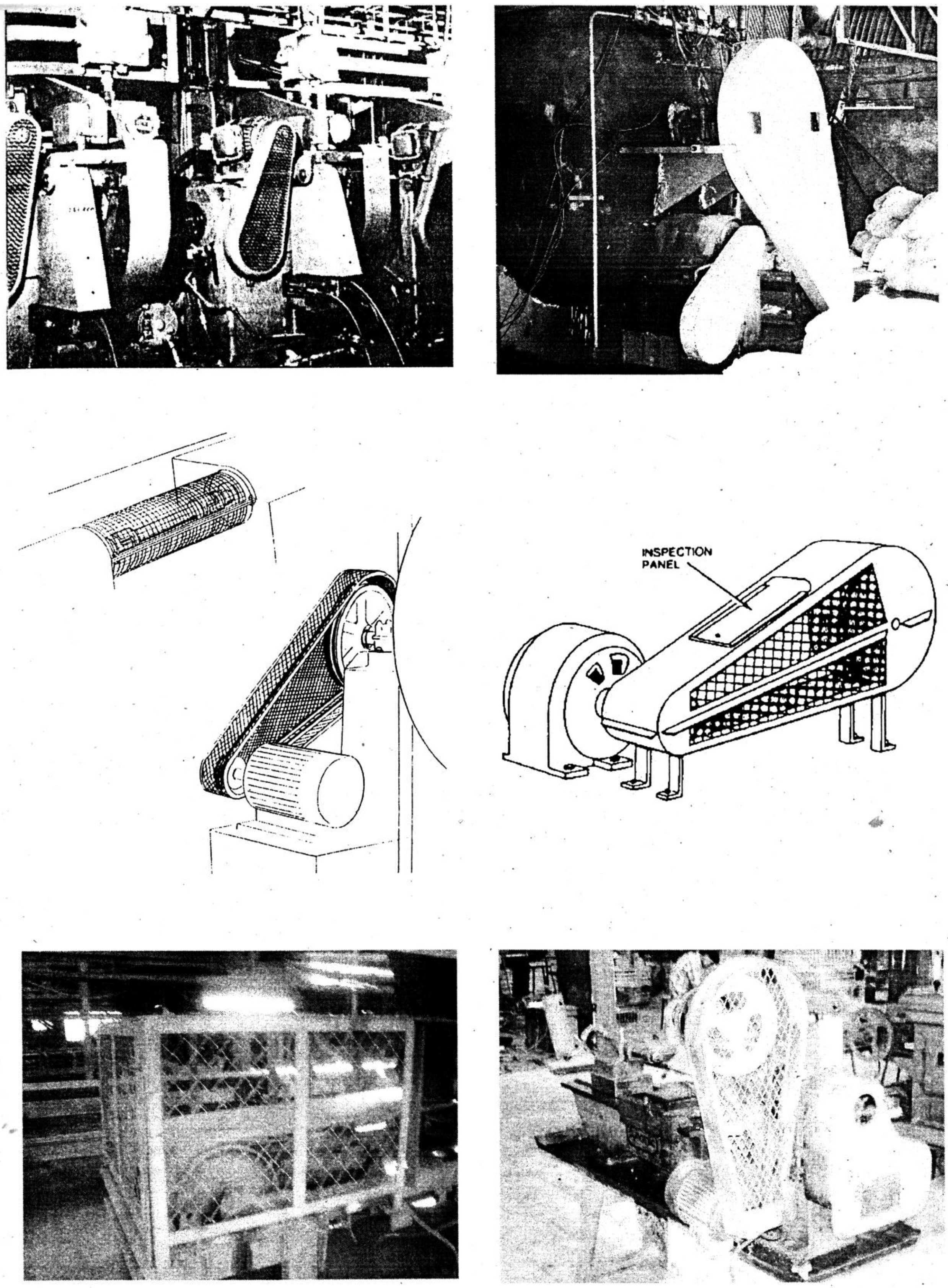


Fig. 14.6 (A) Fixed guards (elemination of hazards).

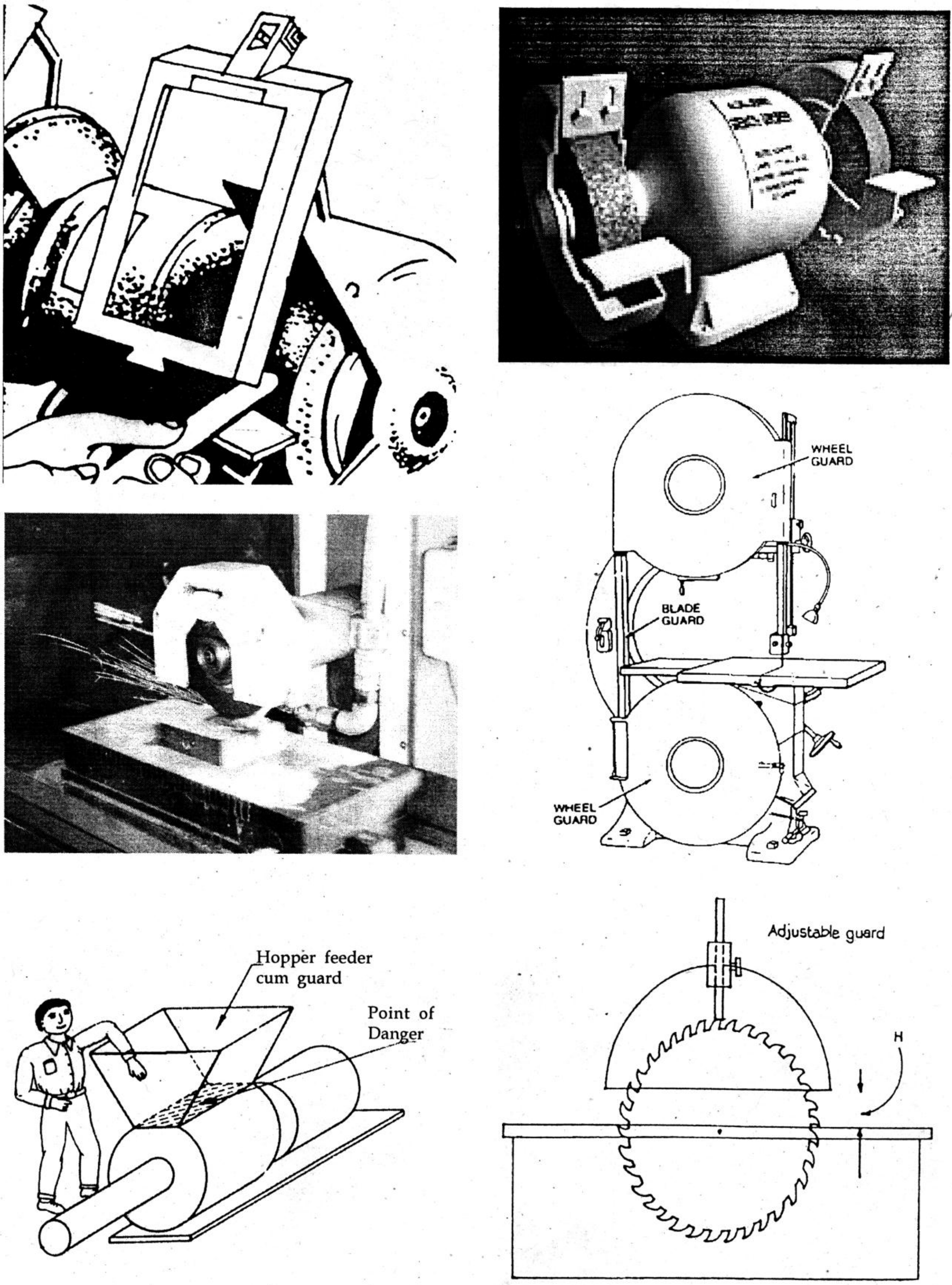


Fig. 14.6 (B) Guards of grinding wheel, circular saw, band saw and rubber mill.

Control guards activate the machine when the guard is closed and opening the guard stops it. Thus the guard acts as on-off switch. Such guard is useful for the machine which can be brought to rest very rapidly, e.g. power press.

Automatic guards will ensure that the operator is prevented from coming into contact with dangerous parts when the machine is set in motion accidentally. This guard is itself actuated by the movement of the dangerous part. It can only be used where sufficient time is available to remove the body part from the danger zone viz. sweep, knock or push away guard on a power press or platen printing machine. Because of its stroke hazard it is hardly used. Photo-electric guard (device) operates to stop the dangerous part when the light curtain is interrupted. This type of guard is used on shearing or cutting machine.

Safety by Machine Controls: These should be differentiated from incidental safety devices which are external and work like guard for protection. But the machine itself has many controls as its inherent or attached elements. All levels, buttons, brakes, pedals, switches, handles, wheels, auto controls etc., are machine controls to run the machine safely and efficiently. Such controls should be clearly identified, marked and suitably placed tot ease of operation. Their purpose and direction of movement shall be marked. Each stop button should accompany start button and they should be sunk to prevent accidental pressing.

Levers should be capable of being locked in position. Levers, handles, or wheels should operate to give naturally anticipated direction (e.g. clockwise close and anticlockwise open, up forward, down reverse etc.), controls should be at rest when power is applied and they should not restart the machine after resetting. Guard or control should be of fail-safe type i.e. the machine will stop if the control fails. When there are more controls nearly placed or on one board clear instruction of their use must be marked to prevent then false operation. Locks or keys on some controls are required to prevent their undesired operation by mistake.

Safety by Precautions and Maintenance: Above paras highlight the need of utmost precautions in safe operation and maintenance of all safety guards, devices and controls. A man has made them and a man can make them ineffective or misuse. Therefore all precautionary operating measures are necessary in addition to the machine guarding. The machine operators should be made aware of hazards in their works, location and operation of machine controls, regular checking of guards, warning and training not to make the guards ineffective, repairs, adjustment etc., by specially trained person, need of wearing tight fitting clothing and protective equipment necessary and using right tools and equipment.

Criteria for Guard Selection : Selection of a guard depends on following factors :

1. Its physical dimensions, weight etc.
2. Method of drive and power requirements.
3. Limitations of speed, pressure, temperature etc.
4. Materials being processed or handled.
5. Access requirements especially for setting, adjustments and maintenance.
6. Environmental factors such as noise, vibration, dust, fumes and
7. Operating requirements such as visibility.

4.2 Built-in Safety Devices :

The object of built-in safety device is to design and make the machine, equipment, method and environment so safe that the workers' exposure- to accident or injury is eliminated or controlled automatically.

It is well experienced that many a times the guards provided on the machines are removed, not refitted and dangerous parts run without guards. Such unsafe practice leads to accidents. Therefore it is always essential to incorporate built-in safety devices (guards) from the design stage so that they become integral part of the machine and subsequent guarding is least required.

Built-in-safety can be designed for point of operation, transmission parts, controls, maintenance, adjustment and cleaning. Unnecessary projecting parts should be avoided. Risk at cutter, tool or equipment should be eliminated or minimised by design, enclosure, handle etc., closed tools are safer than open tools, controls should be in easy reach and inching or slow motion, braking, tripping, reversing etc. should be provided where necessary.

Benefits of Built-in Safety Devices :

1. They are more safe from accident prevention point of view.
2. They serve more than one purpose.
3. They are less costly in long run. Subsequent addition of guards requires frequent maintenance and they are usually more costly and less effective.
4. They provide better standard to the design and operation of the machine.
5. Need for training and supervision to control unsafe acts is reduced.
6. It helps for efficient production, high morale and less labour turnover.

For best results, planning at initial engineering level is necessary. Right from the-drawing and design stage to the delivery stage, all safety aspects should be built-in. The responsibility should also be extended to product design, machine design, plant layout and working conditions, selection and specification of materials, production planning, time study methods, duties of production foreman and the duties of the workers.

The disadvantage of built-in guards is that slight modification or unanticipated circumstances, after machine installation can render the guarding less effective. Therefore necessary correction in safety device should be made if such change is required.

4.3 Incidental Safety Devices and Methods :

Some incidental safety devices (indirect guards) equally useful as machine guarding are as below:

Two Hand control : Two push buttons are required to be operated simultaneously thus keeping the operator's hands engaged and away from the dangerous parts. Such device does not protect another approaching person, is prone to faults and cause difficulties on electrically, hydraulically or pneumatically powered machines. Therefore such device alone is not advisable. It is used on garment presses etc. Where two operators have to work simultaneously, four push buttons are required to keep their hands away from dangerous parts.

Optical Sensor : This uses photoelectric cell and a light. On interruption of light beam, the dangerous part is stopped. Its working must be checked before starting the work.

Electromagnetic Sensor : This uses a sensor of electromagnetic field, a coupler and interconnecting cable and a control unit. Interruption of the field by an operator's hand causes an electric signal which initiates the desired control action.

Mechanical Feed : A positioning device like conveyor or a rotating table moves the parts or material into the point of operation where the hazard exists thus avoiding human contact there.

Feed Tools : Tools viz. tong, magnetic lifting rod etc., are used to place material in a press with an intention to save the hand.

Pedal Guard : Such guard on foot-pedal of a power press prevents occidental foot-stroke on the pedal.

Ultrasonic device : Inaudible high-frequency sound senses the presence of any part in the danger zone. As sound attenuates over distance its application is limited.

Feed Hopper : It extends the feed length to prevent access. It can be used on pug mill, rubber mill etc.

4.4 Guarding of Different Machines :

Some statutory specific guarding is mentioned below under the Guiarat Factories Rules, 1963.

Textile Machinery (Rule 54, Sch. 1) :

Applicability: This schedule applies to machinery to manufacture or process of 'textile' i.e. cloth or fabric. It does not apply to 'Jute Textiles' or manufacture of 'Synthetic Fibres' i.e. yarn. This means it applies to manufacturing of cotton or synthetic cloths.

Definitions : 31 types of textile machines or their dangerous parts are defined. It includes opening, combing, carding, weaving and processing (bleaching, washing, printing, drying, sanforizing, shearing, cutting etc.) machinery. -

Machine Guarding : It is summarised in Table, 14.2

Table 14.2 : Guarding of textiles machines.

	Name of the Machine		Guard / Device Suggested
1	General requirements	1	Individual Starting/ Stopping device in safe position
		2	Belt shifting lock
		3	Guards on all moving parts
2	Openers/ Pickers	1	Interlock guards / doors on beaters and dangerous parts
		2	Feed guards
		3	Nip guards on fixed rolls and lap forming rollers
3	Cotton Cards	1	Interlocking doors on cylinders
		2	Fixed guard on licker-in
		4	Trained worker for stripping or grinding
4	Garnet Machines	1	Fixed guard on licker-ins
		2	Fixed guard on Fency rolls
		3	Screen under garnet
5	Gill Boxes	1	Guard on feed end
		2	Nip guards on rolls (Distances are suggested)
6	Silver/ Ribbon , lappers		Guard on calendar drums and lap spool
7	Speed Frames		Interlock doors on head stock gearing
8	Spinning Mules		Guard on carriage wheels
9	Slashers/ Dryers	1	Nip guards on in-running rolls
		2	Control levers within 1.7 mt from the floor

		3	Stop/ Start push buttons conveniently located
10	Looms	1	Shuttle guard
		2	Beam weigh fall preventer
11	Valve on Kiers	1	Locking device on valve
	Tanks & containers	2	Shut off valves to stop overflow/ splash
12	Shearing Machines		Guard on revolving blades (opening less than 1 cm)
13	Bleaching range		Nip guard on rolls
14	Mercerizing range	1	Stop button at each end of the machine
		2	Guard on frame between chain & clip opener
		3	Nip guard on mangle rolls & washers
15	Centri-fugal extractors	1	Interlock guard on basket
		2	Brake to stop basket
16	Mangles, Washers etc.		Nip guards on in-running rolls
17	Sanforizing and Palmer Machines	1	Nip guards on in-running rolls
		2	Side guards on in-running rolls
		3	Trip rod, cable or wire near cylinders. Height not more than 1.7 mt from working platform.
18	Rope washers	1	Splash guards
		2	Trip rod near washers
19	Washers, tumblers or shakers	1	Interlock door on cylinder
		2	Holding open device for cylinder doors
20	Printing machine	1	Nip guard on rolls
		2	Fixed guards on rollers, gears & wheel
		3	Fixed guards on rollers, gears & wheel
21	Calendars		Nip guard on rolls
22	Rotary staple cutter		Guard on cutting zone
23	Plating machine		Guard on space between knife and card bar
24	Hand baling machine		Handle stop guard at right angle to the frame
25	Flat work ironer		Trip bar/ guard on first pressure (feed) rolls to stop the machine.

Note : See chapter 21 for textile industry.

Ginning, Woodworking and Rubber m/c :

The machine guarding u/r 54, sch 2, 3 and 4 is summarised below in tale 14.3 :

Table 14.3 : Guarding of Ginning, wood working and rubber machines.

Machine		Dangerous Pars	Types of Guards
I Cotton Ginning (Sch. 2) :			
	Line shaft to run the gins	Line shaft	Wall or fencing with locking doors.
II Wood working			
1	Circular saws	The saw	A riving knife of prescribed dimensions and setting. Adjustable top guards, two metal plates guard, push sticks
2	Band Saws	Top and bottom pulleys and the blade	Fixed guards

3	Planning machine	Cutting slot, freed roller	Bridge guard, efficient guard
4	Vertical Spindle Moulding machine	Cutter, the wood being moulded	Suitable guard, A jig or holder
5	Chain mortising m/c	Chain and cutters	Suitable guard
III Rubber Mills (Sch. 4) :			
1	Rubber mill	Inrunning rolls	Height more than 96.5 cm, a distance guard, feed hopper, trip guard (rod) within 1.7 m height.
2	Calendar m/c	Inrunning rolls	Trip guard within 1.7 m height, tight wire cable connected with it.

Note : See Chapter 23 for specific industries.

Centrifugal Machines (Rule 54 Sch. 5) :

Applicability: This schedule applies to centrifugal extractors, separators and dryers but does not apply to similar machines of sugar manufacturing industry.

Requirements:

1. All parts of the machine shall be of good design, construction and adequate strength, properly maintained and examined thoroughly by a competent person at regular intervals.
2. Lid on cage housing, revolving drum or basket shall be strong and interlocked.
3. Effective braking arrangement is required to stop the drum/basket after the power is cut off.
4. Operating speed shall not exceed the rated speed which is stamped at visible places on the basket and the machine casing.

Power Press (Rule 54 Sch.6) :

Applicability : This schedule applies to all types of power presses including press brakes except when used for hot working of metal. The CIF can give exemption by a written certificate with conditions, if any, and he can revoke such certificate also.

Tower-Press' means a machine used in metal or other industries for moulding, pressing, blanking, raising, drawing and similar purposes.

Guarding of Tool & Die : Tool and die shall have a fixed guard so as to prevent hand injury in the danger zone. A small aperture shall be provided at the bottom of the die guard to feed the machine.

An automatic or interlocked guard may be used in place of a fixed guard but it should be maintained in efficient working condition and if such guard develops defect, the press shall not be operated till the defect is removed.

Trained person for testing, preparing etc. : To set, adjust, try out, install, inspect, test or prepare a tool or safety device on a power press, an adult trained worker shall be appointed and his name shall be entered in Form No. 8.

Testing by a Competent Person : No power press or safety device shall be used unless it has been thoroughly examined and tested by a competent person. Periodicity of testing for a power press and its safety devices is 12 and 6 months respectively.

Details of such test report are prescribed in para 6(4) of the schedule. This includes name and address of the factory, name of the occupier, identification number or mark to identify the press or safety device, date of, the first use, date of each examination and particulars of defects found and steps taken to remove them.

Disclosure of Defects & Measures : By any test > or examination, when any defect is disclosed by a competent person, the defective press or safety device shall not be used till it is remedied.

The competent person shall inform the occupier and the Inspector (within 14 days) in writing, the defect to be rectified. The defect shall be remedied and its record shall be kept stating the measures and the date of remedy.

Inspection & Test of Safety Device : After setting, resetting or adjustment of any tool, every safety device of the press shall be inspected and tested by the authorised (appointed) person and then only the press shall be used.

Defect disclosed in a safety device as above, shall be notified to the manager forthwith.

Identification: Every power press and every safety device on it shall be distinctively and plainly marked.

Training & Instruction to Operators : The operators shall be trained and instructed in the safe method of work before starting work on any power press. See fig. 14.8.

Shears, Slitters and Guillotine Machines (Rule 54 Sch. 7):

Guillotine machine has a straight or bevel edged blade and Shearing machine has a similar blade operating vertically, while Slitting machine has circular disc type knives for slitting into narrow strips.

These machines are used to cut metallic or non-metallic substances.

Machine Guarding:

1. The descending blade should have a fixed barrier guard in front of the blade (knife) fitted with the machine frame.
2. Where fixed guard is not possible due to size and thickness of the material being fed, either 'two hand control' or 'push away' device shall be provided for the protection of hands.
3. At the back end, inclined ducting cum guard shall be provided through which the slit pieces would slide and be collected at a safe distance and which would prevent a person from reaching the blade.
4. Except continuous feed trimmers, power driven cutters shall have two-hand starting device (push buttons) and at least one hand on a control during the completion of the stroke. In addition to the brake (stop device), an emergency device shall be provided to prevent the machine from operating in the event of failure of the brake.
5. An automatic guard to push away the hands at every descent of the blade. (Such guard may be preferred as a last resort if other devices are not possible).
6. Where more than one worker work on the same machine, two-hand start device should be for each worker and at least one hand on a control to complete the cut.
7. Circular disc type knives shall have a fixed or manually or automatically adjustable guard to enclose the knife edges. The space between the guard and the material should be less than 6 mm. Portion underneath the table should also be guarded.

Mechanical power press and its machine guarding are shawn in fig. 14.8.

Dangerous Machines : The substituted Rule 57, prescribes the following machines as 'dangerous' and no young person (below the age of 18) shall work on it-

1. Hoists, lifts, lifting machines, chains, ropes, lifting tackles and revolving machinery (Sections - 28,29,30).
2. Power presses other than hydraulic presses.
3. Milling machines.
4. Guillotine machines.
5. Circular Saws.
6. Platen printing machines.

Other guarding is explained in respective Chapters 20 to 23.

5 MATERIALS FOR GUARD CONSTRUCTION

Generally metal is preferred for machine guard construction. Bar, pipe and rod are used for structural frame. Filler material may be solid, perforated or expanded sheet metal or wire mesh. Opening in wire mesh should be as minimum as possible as shawn in fig. 14.7. Where transparency is necessary plastic or glass material can be used. Safety glass and plastics are also used to protect against flying particles and chips.

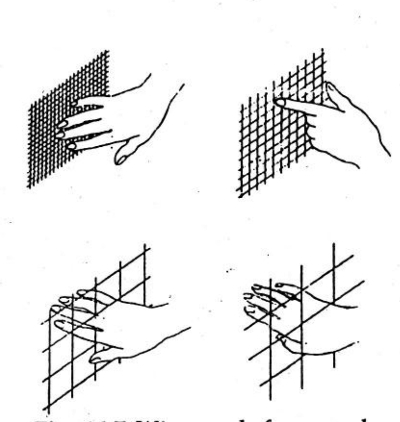


Fig. 14.7 Wire mesh for guard.

Wood guards have limited application due to their poor strength and durability, flammability and high maintenance cost.

Aluminium guards are preferred where rusting or damage to tools or machinery are considerable.

Plastic guards are used where inspection of the moving parts is necessary. Safety glass and plastic used where chips or other flying particles are likely to mar the surface should be protected by replaceable cover glasses.

Whatever material may be selected for guard, it must be sound and durable to withstand impacts, vibrations and other forces.

A floor guard becomes necessary in addition to the enclosure guard to prevent vehicles from straying into the hazard area such as guards on aisles or roadside.

Materials to reduce noise :

Guards are provided near the point of operation and near the transmission of power i.e. near the source of noise. Guards are subjected to vibrations also. Therefore they can make noise. Therefore the guards should be designed as a barrier against noise in addition to a barrier against injury. A common way to absorb sound is to cover the guard frame with sound absorbing material. A gasket type material can be used around the edges to avoid metal to metal contact and noise generation due to it. The guard should be secured with shockproof fittings. Such type of material and proper fitting will reduce the conducted noise. This will be an extra benefit of the guard.

Non-metallic (e.g. plastic) machine parts (e.g. gears) and guards can also reduce the noise.

Well maintenance and lubrication can also reduce the noise.

6 ERGONOMICS OF MACHINE GUARDING

6.1 Meaning of Ergonomics :

As explained by W.T. Singleton in ILO Encyclopaedia, literal meaning of 'ergonomics' is the study, measurement and organisation of work. It is concerned with making purposeful human activities more effective. The focus of study is the person interacting with the engineering environment. The designer should consider complexity arising from human nature and his limitations. To consider human factors, it studies anatomy, anthropometry, biomechanics and psychology as useful sciences. To consider design aspect of work, systems, workspace, environment, interface and work situation, it studies technology. Thus an ergonomist is expected to take an over-all view and identify the key design aspects for particular people engaged in particular tasks.

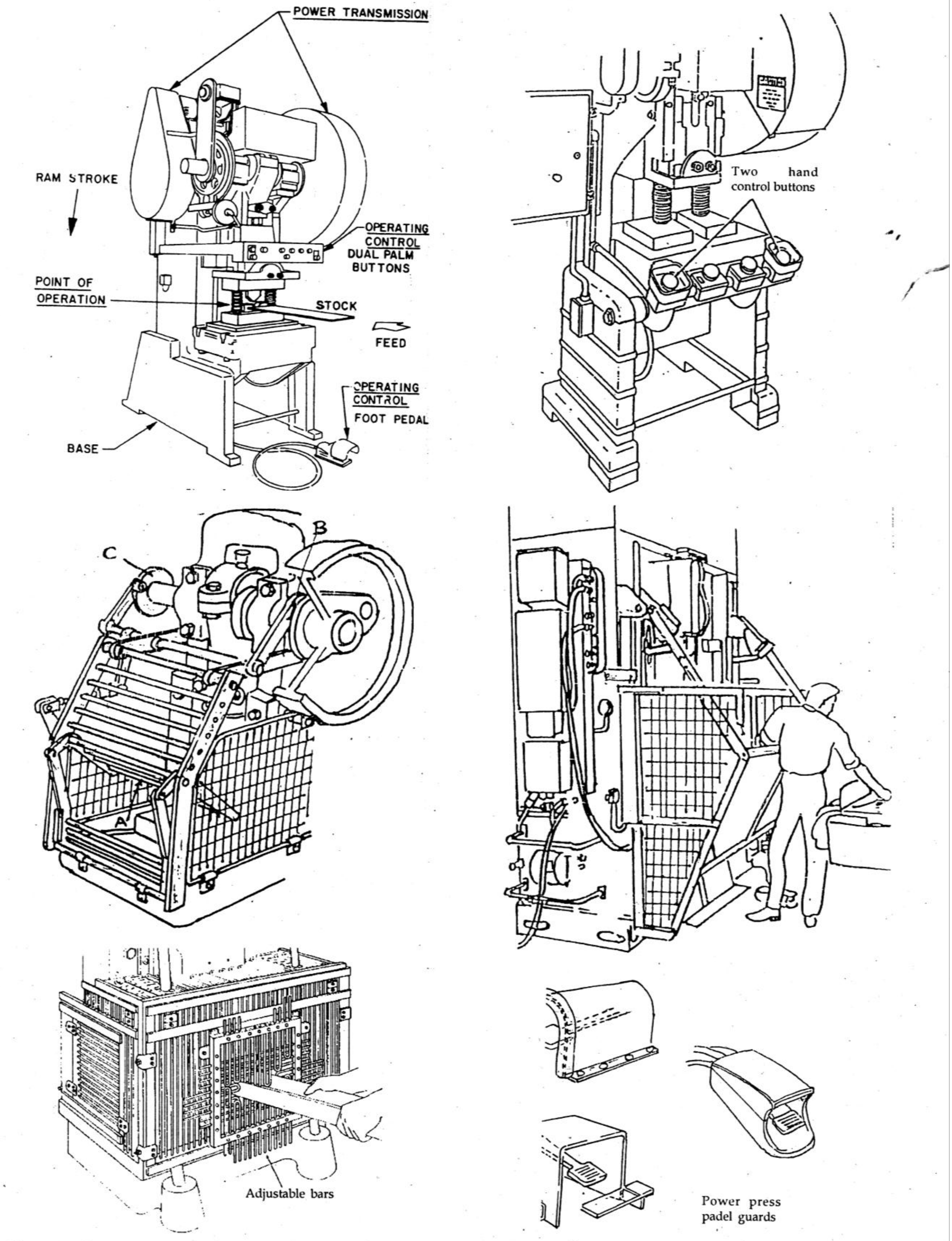


Fig. 14.8 Power press machine guarding.

As explained by K. Kogi, a Regional Advisor to ILO, ergonomics is a useful tool for fitting work to people, not people to work. 'Ergon' means work and 'nomos' means habit of law. Thus ergonomics is for the purpose of solving the problems of work habits. It requires designing of proper workspace, working posture, reach, seat, controls, knob, brake, display, communication, skills, work intensity; sufficient time for rest, good environment, clear understanding and providing platforms or lift tables, carts, transport ways, proper storage racks, buffer stocks, good lighting, ventilation and housekeeping, proper guards and good welfare facilities. Thus ergonomic principles include comfortable posture, balanced and easy motions, adequate rest and enough variety.

As a science, ergonomics studies anatomy, physiology and psychology. Anatomy includes anthropometry and biomechanics. Anthropometry, the measurement of man provides the dimensional data needed for the positioning of controls and the size of work spaces. Statute (height upto head), eye height, shoulder height, elbow height, knuckle height (upto the palm of hanging hand), sitting height, shoulder width, breadth across elbows, upward reach, sideways reach, forward reach, hand length, hand breadth etc., are main human dimensions as stated by W.T. Singleton. Biomechanics is concerned with the application of forces by the human body. This requires knowledge of the locations of the main muscle groups, their composition and their modes of action.

Physiology includes work physiology & environmental physiology. Work Physiology is concerned with the human process of energy production & considers human efficiency, oxygen uptake capacity etc. Environmental physiology provides measures of the stress and standards of reasonable parameters of climate, light, noise, vibration etc. Their effects on human behaviour are studied.

Psychology considers various factors described in Chapter-3 and also some theories such as human performance theory based on an information model of the human operator, learning and skill theory and training and organisation theory for work and system designs. Such psychological theories say about human error - why people make mistakes. Many times guards, controls and protective equipment are provided but operators fail to use them. Why do they do so is an important question which can be replied by psychological study only. Effective audio-visual information, choice reaction times, information processing capacity, memory, attention, understanding, fatigue effects, interaction with other people, morale, group behaviour etc. are useful factors to be considered. If workers are properly educated and trained based on such study, their failure to use guards and safe job methods will be minimised. Such human factors must be considered while designing any machine or work.

Explaining the historical part. King and Magid state in their book (Ref. No. 4 at the end of this Chapter) that this word was first used in 1949 when the society, the Ergonomics Research Society was founded in Britain including anatomists, physiologists, psychologists, industrial medical officers, industrial hygienists, design engineers, work study engineers, architects, illuminating engineers and others. In USA the terms 'Human Engineerings and 'Human Factors Engineerings are used to cover the same field. Biomechanics and Engineering Psychology are other expressions used.

See Part 2 of Chapter-24 for further details.

6.2 Aims of Ergonomics :

Its aims are :

1. To facilitate whatever a person wishes to do and to ensure that he does it comfortably and efficiently. Efficiency includes effective work without detrimental health effects and minimisation of risk to the operator and others.

2. The work, working conditions, plant and infrastructure should be so designed that they are best fitting to the workers. Purpose is not to fit a worker to any awkward, unsafe, unhealthy or uncomfortable work. But the purpose is to design or provide work and working conditions comfortable to the workers.

3. To minimise the possibility of human error or mistake. To ensure industrial activities with minimal use of energy and materials and without waste resulting from mistakes.

4. To develop knowledge and techniques by the combined use of many expertise and systems approach.

5. To solve human problems of work performance by considering human factors in design of machines and work and safe job methods which are explained in the following part.

6.3 Human Factors in Design of Machine and Work:

Technology has changed the people's ways of working but the people are not changed much. Many times the people do not adapt physically and mentally, a tendency of modern work methods. This generates negative reactions which also indicate human factors to be considered by the ergonomists while designing work and machines. Some such factors are :

1. Increased stress.
2. Uninterested work.
3. Errors and accidents.
4. Work related diseases.
5. Awkward body position causing difficulty.
6. Repetitive tasks producing boredom and tiredness.
7. Confusing signals causing human errors in hurry.
8. Bent or awkward posture while handling heavy materials and causing back pain.
9. Perceptual limitation.
10. Short term memory.
11. Incompatibility in man-machine relationship.
12. Risk or chance taking.
13. Position or location not suitable to a worker such as unsuitable work height, seat, layout of control and displays.
14. Organisation of heavy work.
15. Environment.

It may not be possible to incorporate all these factors in machine or work design. Administrative measures, safety training, signs and signals, work scheduling, supervisory observation, plant layout, psychological and medical measures and workers' cooperation may also benecessary.

7 MAINTENANCE AND REPAIRS OF GUARDS

Section 21 of the Factories Act states that the guards shall be constantly maintained and kept in position. Such maintenance is obviously necessary because a machine running without guards or with open or broken guards pose danger. Regular inspection of guards can detect the guard removed, damaged or requiring repairs. A guard removed for repair should be fitted at the earliest possible and meanwhile temporary guard should be installed or the machine be stopped. Good maintenance increases the life of guards and vice versa. The supervisor should pay constant attention for this.

A guard should be so designed or fitted that it is not to be opened for oiling/greasing or nearby maintenance work. The parts needing regular service should be located outside the guard. If oil/grease fittings are inside the guard, an extension through the guard should be provided.

Automatic controls for lubrication, adjustment or service can be provided by a sophisticated equipment. Interlock type guard ensures that the machine cannot be operated unless all guards are in position. Such planning helps maintenance without disturbing guards.

When a guard cannot be made to exclude lint, fume, dusting etc., extra ventilation should be provided. Large guards should have self-closing doors for cleaning. Space should be provided in surrounding for repair and maintenance. Some people use red colour for guards to show dangerous part while some prefer the same colour that of the machine to consider it as an integral part of the machine.

Work on machinery in motion for maintenance purpose :

During maintenance of a machine, normally a guard is removed and observation for fault, alignment, repairing or oiling/greasing is carried out in unguarded condition. Such condition may kill or injure' an untrained or unknowing person. See foregoing Part 1.2, para 'Work on or near machinery in motion' for statutory requirement u/s 22 of the Factories Act.

Zero Mechanical State (ZMS) :

As far as possible this. state (condition) should be observed i.e. all energy sources must be de-energized or made least effective before any maintenance work is to be started. After switching off electrical power, rotating machinery may continue to rotate due to moment of enertia. This may cause accident. The rotating part should come to rest i.e. in stop condition. Therefore mechanical steady state condition (ZMS) should be maintained before starting any maintenance work. This is the safest condition.

Lockout and Tag-out :

This system is used at the time of maintanence or repair work on machine. Power source to the machine is cut off or it is mechanically locked. This is called lockout. A tag is tied with necessary instruction that this machine is under repair or maintenance audit should not be started. This is called tag-out.

For detail see part 6.2.9 of Chapter - II.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. The basic need and importance of machine guarding.
2. The following terms :
   (1) Prime mover (2) Machinery (3) Power (4) Self acting machines (5) Revolving machinery (6) ZMS (7) Point of operation (8) Safety by position (9) Built in care (10) Trip guard (II) Feed tools (12) Two hands control (13) Crown guard
3. The contents of a 'Machine Safety Checklist' as given by NSC, USA.
4. The groups of dangerous parts according to motions OR According to H. A. Hepburn.
5. Characteristics of a machine guard.
6. Principles of ergonomics for machine guarding.
7. Human factors in design of machine and work.
8. Classification of machine guards.

9. Types of fixed guards OR Types of Interlock guards.
10. Different types of Incidental safety devices.
11. Machine guarding for Centrifugal machines OR Power presses.
12. Machine guarding for shears and slitters.
13. Methods of Maintenance and Repairs of guards.
14. General principles of good guarding practice.
15. The effects and acceptability of machine guards.
16. Main mechanical hazards in engineering operations.
17. The restrictions of employment of workers on specified machines and conditions under which the restrictions are relaxed.
18. Methods of eliminating potential hazards from the job.
19. What type of guard would you suggest for (1) Disintegrating machine (2) Rubber mill rollers (3) Open end of a rotating shaft at low height (4) Overhead shaft and pulleys at a height of 10 ft. (5) Basket of a hydro extractor (6) Straw-board calendar machine (7) Cylinder of a carding machine (8) Lap forming rollers (9) Shuttle of a power loom (10) Rolls of a .drying range (II) Jigger machine for dyeing a cloth (12) Mangles of a washing machine (13) Press rolls of a paper mill (14) Rope washers (15) Rotary staple cutter (16) Hand baling machine (17) Band saw (18) Drill tool.
20. What points you will incorporate in placing an order requiring a lathe or shaping machine?

2. Write short notes on :

1. Fencing of machinery (sec. 21, F.A)
2. Work on or near machinery in motion (sec. 22, F.A)
3. Striking gear and devices for cutting of power.
4. Basic steps to prevent accidents.
5. Dangerous parts of rotary motion OR Reciprocating motion and its examples.
6. In-running nips.
7. Human factors engineering.
8. Aims of ergonomics.
9. Criteria for guard selection.
10. Benefits of built-in safety devices.
11. Machine guards for textile machines OR Wood working machines.
12. Testing of dangerous machines by a Competent person.
13. Types of dangerous machines.
14. Materials for guard construction OR Materials to reduce noise.
15. Guarding during maintenance.
16. Quality of guards.
17. Design principles of machine, guards.
18. Safety points while operating a grinding machine OR Centrifuge machine.
19. Machine guarding for rubber mill industry.
20. Advantages of built in guards.
21. Safety points for working on a grinding machine.
22. Types of point of operation guards.
23. Formula for maximum safe opening in a point of operation guard.

3. Explain the Different between (give examples)

1. Machinery & Transmission machinery.
2. Power & Prime mover.
3. Guarding & Fencing.
4. Built in guard & Safety devices.
5. Safety by construction & Safety by position.
6. Interlock guards and Automatic guards.

7. Mechanical interlocking and Electrical interlocking.
8. Safety by Machine controls and Incidental Safety devices.
9. Built in safety devices and Incidental safety devices. ,
10. Control guard and Interlock guard.
11. Push buttons and push away guard.
12. Circular saw and Slitting cutter.
13. Home made guards and Guards made by manufacturer.

4. Comment on the Following explaining whether it is true or not -

1. "Safe by fencing" and "safe by position" is one and the same.
2. Fit work to workers and not workers to the work.
3. Accidents take place due to bad maintenance of machines.
4. Belt hangers are required on overhead shafts.

Reference and Recommended Reading

1. The Factories Act 1948 and the Gujarat Factories Rules 1963.
2. Indian Standards ion Machine Guarding.
3. ILO Encyclopaedia of occupational Health and Safety, Geneva.
4. Industrial Hazard and Safety Handbook, King and Magid, Butterworth.
5. Introduction to Ergonomics, W.T. Singleton, WHO, Geneva.
6. Accident Prevention Manual for Industrial perations, NSC, Chicago.
7. Occupational Health and Safety, M.K. Poltev, Mir Publishers, Moscow.
8. Occupational Safety Management and Engineering, Willie Hammer, Prentice –Hall.

CHAPTER – 15

Material Handling

THEME

1 NEED OF SAFETY IN MATERIAL HANDLING

Material handling is the preparation, placing and positioning of materials to facilitate their movement or storage. In many industries, handling of materials, articles, equipment etc. becomes a main source of injury.

Without handling any material, no production is possible. Lifting, transporting and handling materials, manually or mechanically, is an age-old practice. In Chapter I explaining the Vedic definition of nation, it is stated that enough load carrying vehicles was one of the requirement. In Chapter 7, attention is drawn toward our Indian structures and architecture on mountains and elsewhere, which are the best examples of our ancient techniques of materials lifting, carrying and handling.

Table 5.8 in Chapter-5 states that in India in the year 1990, 12.94% accidents were due to handling goods or articles. This figure was 15.29% in 1991. If accidents due to falling bodies and due to hand tools are added, total 30.31% can be said due to materials and tools handling. From table 5.22 in Chapter-5, it is inferred that total accidents of 1994 in Gujarat due to lifting machine, hand tools, struck by falling bodies and handling goods or articles (total of causation No. 104, 124, 125 and 130 in the last row) were 2686 out of 15683 i.e. 17.12%. This concludes that nearly 18% accidents are caused by material handling.

Studies carried out by the Central Labour Institute, Mumbai, also show that the percentage of accidents caused by material handling in textile, engineering and foundry factories were 16.7%, 23% and 27.7% respectively.

An old Anglo-American Productivity Report says that material handling accounts for 36% of production costs, 50 to 100 tonnes of materials have to be handled for every tonne of finished products and about 2/3 of the' manufacturing time cycle is spent on material handling. Thus its coverage is very wide causing more accidents to men, materials and equipment which ultimately decreases the productivity. Therefore it is rightly said that material handling does not add to the value of the product, but adds to the cost of the product. Therefore to prevent human injuries, material loss, money loss and time loss, accidents due to material handling must be prevented.

Material handling is of two types; manual and mechanical. To avoid unsafe acts and other hazards like slipping, falling, striking etc. in manual handling, it is being substituted by more and more mechanical handling. It reduces such hazards and manpower, and increases productivity.

Hazards of manual handling are due to :

1. Carrying excessive load.
2. Lifting improperly.
3. Unsafe gripping or placing.
4. Struck by falling body or striking against object.
5. Person falling or slipping.
6. Failure to wear PPE.

Hazards of mechanical handling are due to

1. Wrong selection of equipment.
2. Design defect or unsafe construction or operation of equipment.
3. Overloading of equipment
4. Wrong position of material or equipment.
5. Working at excessive speed.
6. Lack of space for operation.
7. Lack of skill, training and correct attitude on the part of operator.
8. Improperly guarded or unguarded machinery.
9. Electrical faults and
10. Poor maintenance or no testing.

Accidents can be avoided by good training and supervision, periodical examination of equipment and medical examination of workers. To study material handling problem, safety professionals should study

1. Possibility of eliminating or reducing manual handling or its defects.
2. Possibility of mechanical handling.
3. In what ways injury possible? .
4. Handling aids-hooks, trucks, trolley boxes - to make the job safer.
5. Protective equipment or clothing to help prevent injuries.
6. Need of training to workers

2 MANUAL HANDLING

2.1 Statutory Provisions :

Maximum Liftable Loads:

Person	Permissible Max. Weight (Kg)
Adult male	50
Adult Female	30
Adolescent male	30
Adolescent female	20
Male child	16
Female child	13
Two adult workers working together for carrying load by handcart	500

Rule 62 of the Gujarat Factories Rules prescribes the following maximum loads that could be manually carried or lifted (Notification dated 7-6-2001)

Rule 38 of the Building and other Construction Workers Central Rules, 1998 also prescribes the same limits for building workers. See Part 7.2 of Chapter-28.

It is also clarified that no adult male, adult woman, adolescent or child shall engage, in conjunction with others in lifting, carrying or moving by hand or on head, any material, article, tool or appliance if the weight thereof exceeds the lowest weight fixed by the above table for any of the persons engaged multiplied by the number of persons engaged. Thus two male children cannot be engaged to lift mdre than 16 x 2 = 32 Kg, five adolescent females cannot be engaged to lift more than 20 x 5 = 100 Kg and so on. Actually this should be still less considering 'coordination losses'.

However, it is true that looking to the variety of differences in persons of the same age and same sax, they differ in their capabilities. Personal and climatic factors also have effect (e.g. heat stress, cold stress, discomfort etc) on them of the same age and sex, different persons can lift different amounts of weight because of their body built, practice, height, weight structure etc. Work load condition, shape, size (job safety analysis) and personal health should also be considered in deciding lifting standards.

Nevertheless, from safety and legal point of view, it is necessary to prescribe some reasonable safe limits based on scientific criteria. Otherwise exploitation of workers requiring them to lift any amount of load is possible. This may result in accidents, injuries, absenteeism and leaving the job.

2.2 Indian Standards :

While handling materials manually, personal protective equipment for various body parts are necessary as per requirement. See Part 3 of Chapter 25. Still a few IS are mentioned below :

Leather for leg guards 3946, for garments 12718, leather shoes, non-slip, oil resistant rubber soles 11543, leg and foot safety equipment selection 6519, 10667, Gloves - disposable 7180, chrome leather 5866, leather gauntlets and mittens 2573, rubber - surgical 4148, post-mortem 4149, safety industrial 6994; Gloves and mitts, insulating materials for live working 13774, Electrical purpose rubber gloves 4770, Rubber aprons 4501, Safety equipment for arms and hands 8807.

Guide for selection of body protection 8519, Safety belt and harnesses 3521, Protective leather clothing 6153, Eye protectors 5983, Face shields 8521, Leather safety boots and shoes 1989, Protective gaiters 2472, footwear for steel plant 10348, PVC boots 13038, 13292.

Safety helmet 2925, Respirators glossary 8347, Selection, use and maintenance 9623. Breathing apparatus 10245. Life jackets 6685.

2.3 Kinetics of Manual Handling :

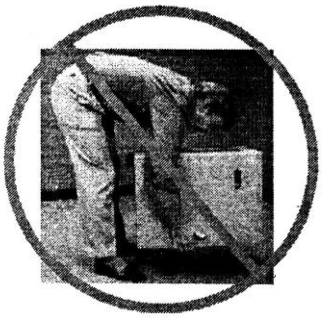
In manual material handling human body acts as a machine (lever mechanism) and undergoes forces and torque. Therefore stress and strain occur and if work goes beyond one's capacity, pain, fatigue or injury results.

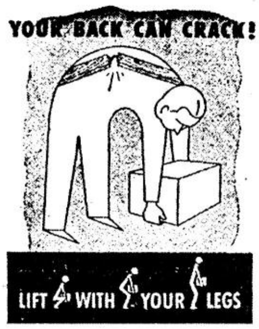
Types of adverse effects or injuries associated with manual material handling are strain, sprain, back pain, cuts, bruises, burns, fracture and non traumatic injuries occurring after a long time.

Therefore it needs to understand kinetics of manual material handling. Lifting and carrying exert strains to the body. The body can be kept erect only by tensing muscles. Even while walking on slopes or stairs, considerable effort is required. '

Carrying load imposes a static strain on muscles of arms and trunk and also on back and heart. Muscles are also engaged while holding the load and cause fatigue. Serious fatigue results in reduced output and may cause accident.

Clinical investigations carried out by Schroter on groups of manual handling workers and office workers shown effects on skeletal system such as in the spine elbow joints, knee joints etc. While lifting load, lumber discs are affected much.





The lifting system of the spine can be represented as a double armed lever arrangement in which the force of the back muscles is applied to the ends of the spinous process, which are about 5 cm long. According to the principles of levers, the force exerted by the back muscles must be 8 or more times the resistance represented by the load. The strain borne by the disc exceeds that exerted by the back muscles by an amount equal to the weight of the load. It has been noticed that on men between 20 to 35 years, a disc stress of over 30 kg/ m2 can be damaging.

Lifting lighter loads with jerks is also harmful and may cause spinal pain.

2.4 Safe Methods of Lifting and Handling :

They are necessary to minimise physiological stress and accidents while handling materials of different size and shapes.

2.4.1 Avoidance of Excessive Muscular Efforts

Adverse effects due to manual handling are explained in brief in Part 2.3.

Careless or wrong manual load handling causes injury to the spinal column and adjacent muscles, particularly the lumber region. It may also cause pulse rate rise, blood pressure rise, brain haemorrhage, abdominal hernia, back pain and ptosis of abdominal organs. When excessive loads are regularly carried from an early age, the constant stress and strain on

muscles, ligaments, joints and bones can cause deformities such as scoliosis or kyphosis in the vertebrae, damage to the arch of the foot and inflammatory and painful conditions of the muscles and bourse. Constant pressure on the skin, muscles or nerves leads to callosities, neutric pains or paralysis, hypertrophy, back trouble, heart enlargement, hardening of the blood vessels and hypertension. Women are much affected than men and in children it may affect bodily (skeletal) growth. Therefore avoidance of excessive muscular efforts is utmost necessary.

Wrong handling

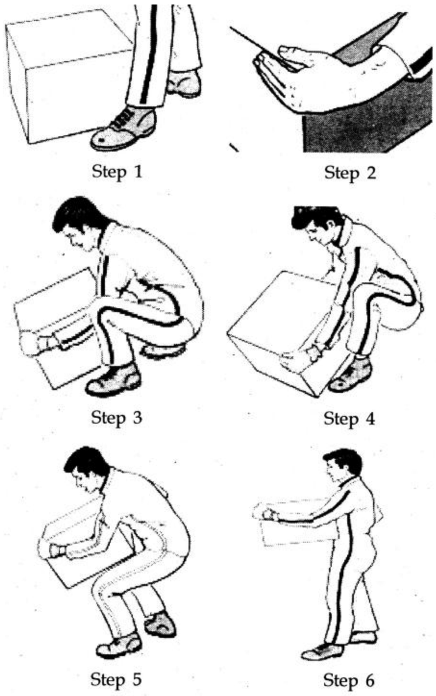
Back pain due to manual handling results in absenteeism. Lundgren questioned 1200 Swedish workers who had been absent because of back trouble. Those engaged in heavy work reported more absenteeism from back complaints as those employed in light work. Kramer has estimated that overall 20% of all absenteeism is caused by injury to discs and this account for half of all premature retirements. Further research (Davis and Stubbs) has shown a close relationship between forces acting on the lower back and pressures generated in the abdominal cavity. They have found 'that the workers whose abdominal pressure was found in excess of 100 mm of Hg, had significantly high incidences of back pain.

Based upon observations on some 700 British male subjects, a guide was issued by the Material Handling Research Unit, University of Surrey which gave force limits for lifting, pulling and thrusting. By using this guide, work practices can. be designed so as not to exceed the maximum limiting intra-abdominal pressure, 90 mm of Hg and thus indirectly reduce the possibility of back pain.

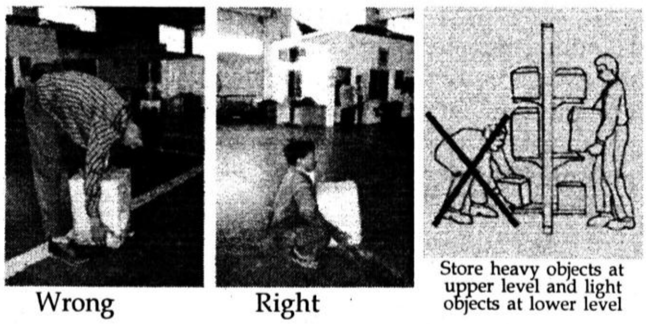
Age and sex affects .the efficiency. After the age of 30 efficiency declines. Women have weaker muscle power than men and are shorter in height. Hence their reach is less and the maximum physical capacity of a woman is about 2/3 of a man's.

Steps of Kinetic Method of Lifting are :

1. One foot ahead of the other in the direction of the movement.
2. Grasp the load from the palm and not from the root of the finger
3. Keep back straight, not necessarily vertical.
4. Keep the load close to the body.
5. Start lifting with the thrust of the rear foot, keeping the object close to your body as you lift with your legs, not with your back.
6. Keep the head in correct position. It is also necessary to keep the centre of gravity of the load as near as possible.



Safe method of Lifting :



1. The feet should be placed close to the load and properly spaced for body balance.
2. Back straight and as nearly vertical as possible. Elbows as straight as possible. Knees bent until the hands reach the proper place for gripping the load.
3. Grasp the load firmly. Lift should be completed by straightening the knees, keeping the load close to the body.
4. While putting down the load, above procedure should be reversed. .
5. Banding upto ground level should be avoided. , Support at hip level (3 to 4 ft.) is necessary.

Safety precautions while Manual Handling :

1. Movement should be in horizontal plane. Push and pull is preferable than lift or lower. Before lifting, the distance to be travelled and the time of grip should be considered.
2. Lifting or lowering should be between knuckle (hip) height and Shoulder height, it should be close to and in front the body. Bending or twisting of body causes overexertion injuries.
3. Material should be light, compact and safe to grasp. It should not have sharp edges, corners or pinch points.
4. Material from bin or container should be easily removable. The operator needs not to dive into the container to reach the material. Containers of chemicals should be properly closed.
5. If load is too heavy, use mechanical lifting device or take help from somebody.
6. Get the load close to the body and feet also close to the body. Stand in a stable position with the feet pointing in the direction of movement. Lift mostly by straightening the legs.
7. Temperature of the material, floor and work area. should be comfortable. The floor should not be slippery.
8. Use proper hand, eye, leg protection and respirator if necessary.
9. Keep hands free from oil and grease. Clean the material if it is slippery or dirty.
10. Handle with firm grip. Keep fingers away from pinch and shear points.
11. Don't lift or lower awkwardly or by twisting the back or bending sideways or by extending the arms. Don't continue if the load is too heavy.

Workers should be trained for correct manual handling. They should know the weight to be lifted, position of centre of gravity, their capacity to lift, distance to be carried, physical hazards of the material such as sharp edges, size, brittle, slipperiness, greasiness etc., PPE necessary and chemical hazards including temperature and health effects.

Team Work in Lifting : When the load is beyond one man's capacity, more persons are engaged. Then the team workers should ensure that the load is within their total capacity. Team workers should be nearly equal in height, size and physique and the lifting should be done simultaneously. If necessary, one should act as a leader or signalman to guide others.

Long sections should be supported on the same shoulders (with shoulder pads) and walking should be done in step. It should be noted that the total load that can be lifted is not the sum of each person's capacity. J.F. Dashiel (1935)'s study had noticed coordination loss in team work as it is unlikely that each person in the team would exert his maximum force exactly at the same time. Hence if one person can lift 55 Kg, two persons can lift 100 Kg (not 110 Kg), three persons can lift 140 Kg (not 165 Kg), six persons can lift 210 Kg (not 330 Kg) and so on. But this cannot be always so, as motivation can change the situation, their minds are concentrated on some word or slogan or their efforts are properly united.

2.4.2 Lifting and Carrying of Different Objects :

Their methods are briefly as follows :

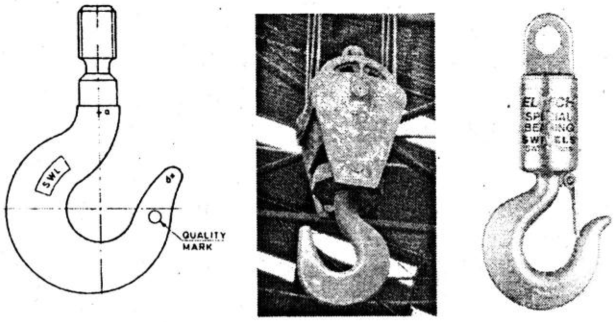
1. **Boxes and Cartons :** Grasp .them at opposite top and. bottom corners. Draw a comer between legs.
2. **Barrels and Drums :** Two men stand on opposite side. Grasp both chimes near the high point - up and while pressing down the bottom and straighten up with the drum.

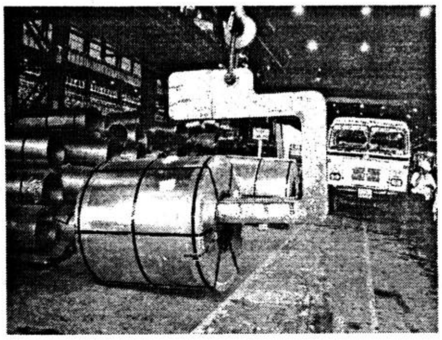
   Handling on incline - Use ropes and tackles. To control motion, pass a rope around a drum. One end of the rope should be fastened to the platform at higher level. A worker keeps a firm grip on the free end, then gradually lower or raise the drum along the risers.
3. **Sheet Metal :** Handle with leather gloves, hand leathers or gloves with metal inserts because of sharp edges and corners.
4. **Sheet Glass :** Handle with gloves or hand leather. Cover wrists and forearms with long leather sleeves. Leathers, or canvas apron and guards for feet and ankles should be worn. Carry the glass sheet with the bottom edge resting in a palm turned outward and with die other hand holding the top edge to steady it or balance it. Never carry glass sheet under the arm because fall might sever an artery.
5. **Long Objects :** Long pipes, barstock, lumber should be carried over the shoulders, with the front end held as high as possible to prevent striking. Other employee should guide when going around corners.
6. **Irregular objects :** If it is difficult to handle because of its shape or weight, assistance should be given.
7. **Metal Scrap :** Wear goggles, gloves or hand leathers, safety shoes and skin guards. Workers should be cautioned against tripping or slipping on objects which may roll or slide under feet. Mechanical handling of this commodity (magnetic lift crane) is preferable.

Heavy machines, round, flat objects etc. need specially trained workers. Specially designed truck, trolley or device is required.

2.5 Safe Use of Accessories for Manual Handling :

Each tool or other device should be kept in good repair and used for the job for which it is designed.



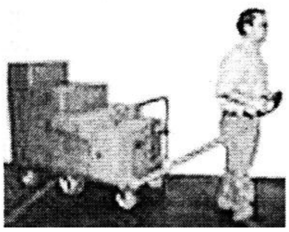


(1) **Hooks :** Danger of glancing off hard objects. When carried in a belt, the point should be covered. Sharp point necessary for handling bags, logs, crates, boxes etc. should be protected.

(2) **Crow Bar :** Main hazard is slipping. Point or edge should have a good bite. Proper position of hand and body to minimise chances of hand pinching or worker falling if the bar slips. Never work astride a crow bar. When not in use, keep on a rack.

(3) **Rollers :** Heavy or bulky objects are often moved on the rollers. Main hazard is fingers or toes getting pinched or crushed between the roller and the floor or the roller and the object, when the direction of the roller is changed. To move a roller under load, use a sledge or a bar, never hand or foot.

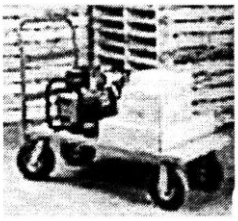
(4) **Hand truck and wheel barrow :**
It has mostly 4 or more wheels.




1. Knuckle guards to protect jamming of hands against door frames or other obstructions.
2. Wheel should be under the truck if possible to save injuries to toes and feet. Wheel guards are preferable.
3. Provide brakes to avoid holding a truck with a foot on wheel or axle.
4. Inspect daily and keep in good repair.
5. No one truck is right for handling all types of material. Select appropriate one.
6. Loaders should keep their feet clear of wheels. Load should be so placed that it will not shift, fall off or block clear view ahead.
7. On two wheelers, centre of gravity of load should be placed well forward.
8. Four-wheelers should be pushed and not pulled.
9. Avoid collisions especially at blind corners. Use mirror at corner.

10. Do not. park trucks in aisle ways so as to obstruct traffic or causing stumbling hazards.

(5) Hand Trolley:

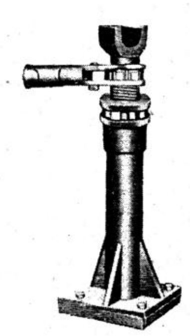


It has mostly 3 to 4 wheels.

1. Cover floor holes or remove bumps and make it even to prevent trolley from jumping.
2. Provide rubber tyres on wheels to minimise noise and damage to flooring.
3. Load should be evenly distributed to prevent tilting.
4. Don't overload trolleys. It is unsafe.
5. Load height on trolley should not obstruct vision.
6. Secure load on trolleys with ropes, stay blocks etc. wherever necessary.
7. While going up on slope, pull up the trolley and while going down on the slope push down the trolley.
8. Trolley handles should be held at the front artd not on the sides to avoid knuckles getting bruised due to contact with wall or machine etc. If the trolley handles are to be held on sides, provide knuckle guards.
9. Pathways should be clearly marked in white or coloured lines.
10. Park trolleys in such a way that they do not obstruct passageways.

(6) Jack:

An identifying plate showing lifting capacity should be visible. It should be painted or marked on it and never be exceeded. If hydraulic fluid leaks, that jack should be removed from use. Jacks should be lubricated only at points required. They should not be thrown or dropped. The resting floor should be checked for load bearing capacity and level. A hard wood insert should be used between the jack head and the load to avoid metal to metal contact. After the load is raised, metal or heavy wooden stands should be placed under it for support and risk of lack slipping or falling. To raise a large sized load, two or more jacks should be used, but they should be equally raised. Workers should wear safety shoes. Oil spiUage should be cleaned before and after the work.



2.6 Storage and Handling of Materials:

Floor conditions and safety in storage, loading and unloading are important.

2.6.1 Safety in Storage of Materials:

1. **Bagged Materials :** Cross ties with mouths inside. When pile is five feet high, step back by one row for each additional three feet. Do not remove a bag from a lower row first Prevent fire risks.
2. **Pipe and Bar Stock :** Consider strength of the floor. Pile in layers with strips of wood or iron between layers. Strips should have block at one end or one end turned up. Bar steel stock would be stored in racks inclining towards the back to prevent rolling. The stack height should be limited to 2 mt. Buttons should be placed between tire of bundles to facilitate slinging. Heavier bars should rest on rollers. Light bars may be stored vertically in a rack.

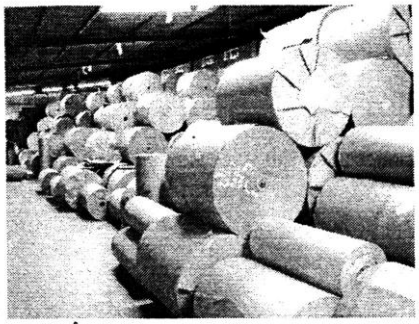
3. **Barrels and Drums** :- Pyramid shape is safe Bottom row should blocked when stacked on sides. If piled on ends. i.e. up right, planks

should be laid between rows. Strength of the drum, its size, shape and weight should also be considered.

4. **Metal Sheets and Plates :** If the sheets are i bundles and of fairly standard size, they can be safely stacked upto 2 mt height with buttons between each bundle. Sheets of random size should be stored in toast racking form. Heavy steel plates of more than 4 feet width should be laid horizontally. With plates of varying sizes, the largest ones should be at the bottom and the smallest on the top. Use leather gloves or gloves with metal inserts to hold sharp edges and corners.

5. **Long Objects :** A pile of lumber (bamboo, timber) should not be more than 20 feet high. Tie pieces are needed not only to stabilise the pile but also to provide air circulation. These pieces should not extent much into gangways.

6. **Cartons :** Loaded cartons should be stored on platforms or shelves to protect against moisture or breakage. When the sides are of unequal size, the tires should be so laid as to give natural bonding and provide stability. If natural bonding is not possible provide artificial bonding by a sheet or a wrapping paper placed between two layers.



7. **Paper Reels :** Fork lift can be used to store reels on ends. For stacking on ends, a well leveled floor is essential and the reels should be of the same diameter. Reels may be stored in horizontal position in nesting tires. Then the first or bottom row should be blocked to prevent the rolls from shifting.

8. **Liquid Chemicals :** Portable containers such as drums, barrels and carboys should be stored and handled carefully. Store room should have impervious walls and floors and provision for safe disposal of spillage. Before handling, check corrosion of nails or weakening of packing by the chemical. For transporting carboys use a carboy trolley. Safe way to empty a carboy is to move liquid by suction from vacuum pump or start the siphon by means of rubber bulb. Properly designed carboy inclinators are also satisfactory. Before piling empty carboys should be thoroughly drained and stoppers replaced.

9. Gas Cylinders:

1. Cylinders may be rolled on the bottom edge but never dragged.
2. Carry cylinder in a cradle or in a suitable type of carrying device.

3. Do not permit them to strike each other violently. Tie vertical cylinder by chain.
4. While returning empty cylinders or when not in use, close the valve and replace valve protection cap.
5. Always consider cylinders as full and handle them with care. Do not store gas cylinders in the sun or excess heat.
6. Follow the Gas Cylinder Rules 2004, IS:5903 and other Indian Standards.

10. Handling of Hazardous Material / Dangerous Substances/Chemicals:

USA Code (Title 49, Code of Federal Regulations) defines hazardous material as "Any substance which has been determined to be capable of imposing an unreasonable risk to person or property". It further states that "No person may offer or accept a hazardous material for transportation in commerce within the United States unless that material is properly classed, described, packaged, marked, labelled and in good condition for shipment.

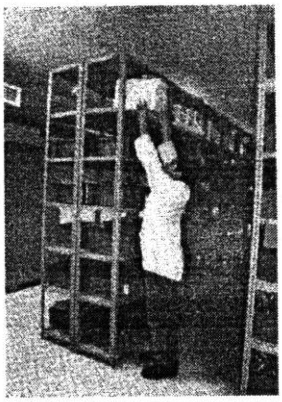
1. Dangerous substances should be handled and stored under the supervision of a competent person who is familiar with the risks and the precautions to be taken.
2. In case of doubt as to the nature of the risk or the precautions to be taken, the necessary instructions should be obtained from the MSDS and the competent authority.
3. When dangerous substances are to be handled or stored, the workers concerned should be given adequate information concerning their nature and the special precautions to be observed in handling them.
4. Special precautions, such as the provision of mats, sling nets, boxes and high sided pallets should be taken to prevent breakage of or damage to containers of dangerous substances.
5. If containers of dangerous substances are broken or damaged to a dangerous extent, work should be stopped and the workers concerned removed to a safe place until the danger has been eliminated.
6. When highly flammable material is being handled, special measures should be taken to ensure that an incipient fire can be controlled immediately.
7. When necessary, non-sparking tools should be provided and used in explosive atmosphere.
8. Where corrosive substances are handled or stored, special precautions should be taken to prevent damage to the containers and to render any spillage harmless.
9. Workers handling harmful substances should thoroughly wash their hands and face with soap and water before taking any food or drink.

2.6.2 Safety in Stacking and Un-stacking :

Neat and orderly stacking or un-stacking minimise hazards and conserve space. Materials piled haphazardly increase accidents and damage to materials. Planned material storage reduces time to bring raw materials into production and to remove finished products from production. The warehouse supervisor should direct the proper stacking and un-stacking.

Adequate ceiling clearance under the sprinklers, side clearance to keep free and clear the electrical panel boxes, switches and other controls and unobstructed access (passageways) to fire hoses and extinguishers must be maintained. All the exits and aisles should be kept clear. Codes on installation of sprinkler systems should be referred for clearance between the storage and the sprinkler heads.

Loading and unloading areas and aisles should be kept clear i.e. no material should be stacked there. Aisle width should allow for the turning radius of any power truck to be used. These areas must be marked or painted with lines.



Unsafe

Safe

Racks, stands, shelves, platforms and bins should be provided to facilitate storage and reduce hazards, e.g. bromine bottles on shelves. Damaged racks should be repaired soon. Workers should not climb racks.

Height indicating line should be painted on wall to show maximum limit of stacking. This helps keep the floor load within limits and sprinkler heads in the clear.

High rack (bay) storage requires unique, specially designed and high lift handling equipment. Upto 30 ft (9 mt) heights manually operated and for more height computer controlled equipment are available. Audible and visual warnings on moving equipment are necessary.

Toxic materials should not be stacked with flammable materials. Volatile material should be kept in a cool shed. Boxed carboys should not be stacked higher than 3 tiers and those of strong oxidising materials, not more than 2 tiers. Incompatibility should also be checked. Proper and sufficient fire fighting arrangement should be provided in and around the storage.

Lifting hoist cage should have safe lift way. It should be so enclosed that material cannot fall on Workers. Landing platforms must have safe guard rails to prevent material to fall from opening.

If two overhead travelling cranes are operated at the same height and on the same rails, limit switches, buffers and alarms must be provided to maintain their safe inter distance and Driver's cabins should face each other.

Paper or cloth rolls, barrels, cylinders and materials which may roll or slip must be stacked safely. Begs and boxes must be kept cross tied and not overhang. Containers must be well marked with the content to avoid mistake in their identification.

Proper ladders, platform and inters tacking containers should be used.

2.6.3 Floor and Lay-out Conditions :

1. **Floors :** Depending upon the load and type of operations, the conditions of the floor such as (a) Cleanliness (b) Absorptive qualities (c) Marking (d) Colour (e) Non-sparking of static disseminating properties and (f) Durability will give great effect on material handling.

   Floor used for stacking should be of sound construction, well maintained, levelled and facilitating drainage. Ground should withstand all weather conditions for the load to be imposed. Stacks should not be built close to railway tracks or in the vicinity of vibrations or possibility of fire.

2. **Walls :** Generally walls are not retaining walls. Therefore load should not be stacked against walls or leaning to wall. A clearance of 18" from wall facilitates inspection of stacks and avoids stacks touching the walls.

3. **Construction of Stacks :** Height base ratio, size, shape, bulk, weight, type, rigidity and fragility of materials and availability of space influence the size of stacks. Normally height should not exceed three times the narrower width.

   Bonding articles in the stack is useful for me stability. Interlocking provides natural bonding. Artificial bonding uses materials like battens, canvas sheets etc. between the tires.

   Stacking should not obstruct fire alarm boxes, sprinklers, controls, fire extinguishers, first-aid boxes, switches, fuses, lights etc. Exits and aisles must be clear. Clearance below sprinkler heads should be more than 2 ft. It should be large enough if the material being stored is inflammable.

   Aisles having one way traffic should be more than 3 feet wider than the widest vehicle when loaded. If the material is to be handled from aisles, turning radius of the power truck should also be considered. Marking line on wall to indicate maximum height of stacking keeps the floor load within limit and the sprinkler heads with clearance,

4. **Lighting :** Inadequate light is a factor behind many slips, falls and injuries. There are various types of light fittings available and these should be selected and used for specific work or areas. The required levels of illumination for different operations are given in Chapter-9. All stores, godowns, yards, workrooms and places of material handling should be properly illuminated.

5. **Ramps :** Ramp gradient should not exceed 1 in 10. It should not be slippery, uneven or broken. It should have sufficient width.

6. **Obstructions :** Pipes, conduits, drains, valves, fire apparatus, etc., are necessary parts of plant structures, yet they often cause hazards. In planning the plant, such parts should be so placed that they may cause minimum interference with persons or materials.

7. **Ladders:** Do not climb on stock-piles. Use ladders. Fixed ladders are preferable. If the height exceeds 2 m provide railing and hand-tools pocket for the ladders. Portable ladder should have non-slip base or its bottom should be held, tied or securely anchored to prevent slipping.

8. **Bridge plates :** Bridge plates should be of adequate strength and they should always be properly anchored.

2.7 Ergonomics of Manual Handling and Storage :

Ergonomics, human factors or human engineering is the study of human characteristics for the appropriate design of the living and work environment. Human characteristics include capabilities, limitations, motivations and desires. Hence, ergonomics is human-centred, trans-disciplinary and application oriented science. Scientific principles, methods and a variety of data are used to develop systems more suitable to people and successful application is measured by improved productivity , efficiency, safety and acceptance of the resultant system design. The user-oriented design philosophy considers human variability as a design parameter and incorporates built-in safe guards to avoid or reduce the impact of unpredictable human error.

Psychology, physiology, biomechanics, anthropology, science and engineering are the main disciplines to be considered in ergonomics.

Work physiology takes into account capacity for physical work. and its energy cost, heart rate at work, matching people and their work, rating the perceived effort, work/rest cycles and fatigue.

Anthropometry ' measures human body dimensions for work and biomechanics explains strength of human body in mechanical terms. It considers muscle strength and its method of working. It is this muscular strength which is mainly used in manual material lifting and handling.

Four keys 'explained by Kroemer (1984) for ergonomics of manual handling are as follows : 3

1. Improved facilities of good layout provides safe and efficient material transfer.
2. Job or task design should consider stress on the worker and should decide whether to assign certain tasks to a person or a machine.
3. Selection, use and improvement of equipment, machines and tools strongly affect material handling requirements. Space requirement, control device, visibility, colour and sign coding etc. should be considered.
4. System must be designed for people as they are king pins of material handling. Their body size, strength and energy capability should be considered.

These four keys provide systematic analysis of material handling problems and many of the risks and strains can be avoided or reduced by intelligent job design, selection and use of equipment and well designed facilities.

See Part 3 of Chapter-24 for more details.

3 MECHANICAL HANDLING

For overall understanding, a classification of material handling process and equipment is given below:

- Material Handling
  - Manual
    - Individual or Team-work. Accessories. Storage and Handling of Specific Materials
  - Mechanical
    - Lifting Equipment
      - Hoists and Lifts
        - For man
        - For material
      - Lifting Machines
        - Cranes, Crabs, Winches, Pulley-blocks, Derricks, Overhead crane, monorail
      - Lifting Tackles
        - Slings, Rings, Hooks, Shackles, Swivels, Couplings, Sockets, Clamps, Trays
    - Transport Equipment
      - Mobile Crane (Crawler, Tyre mounted. Hydra)
      - Industrial Trucks
        - Platform, Pallet, Fork-lift, Reach, Tractor-trailers, Hand lift trucks. Wheel barrows
      - Conveyors
        - Belt, Slat & Apron, Flight, Chain, Screw, Bucket, Pneumatic, Aerial, Portable, Gravity, Chutes, Live roll, Vertical, Pipelines &: pumps
    - Others
      - Mechanical Shovels, Elevators, Escalators

Manual handling is discussed in previous part. Mechanical handling is discussed below.

3.1 Statutory Provisions :

They are as under - .

3.1.1 Factories Act and Rules :

Section 28 and 29 of the Factories Act are regarding hoists and lifts (with platform or cage and fixed way) and lifting machines and tackles.

Difference between 'Lifting machine' and 'Lifting tackle' is explained at the end of sec. 29.

Lifting machine means a crane, crab , winch, teagel, pulley block, gin wheel, transporters or runaway. For figures see Part 3.5.1.

Lifting tackle means any chain sling, rope sling, hook, shackle, swivel, coupling, socket, clamp, tray or similar appliance, whether fixed or movable, used in connection with the raising or lowering of persons or loads by use of lifting machines. For figures see part 3.5.2

Above explanation clarifies that lifting tackles are used with lifting machines and hoists and lifts are not included in lifting machines. Therefore Form No. 9 is prescribed for hoists and lifts and Form No. 10 for any other lifting machine.

The word lifting gear is used to indicate any item which is used fo connect aload to a lifting machine or appliance but which is not in itself capable of providing any movement to lift or lower the load. It is also known as lifting appliance, lifting tool or lifting tackle.

There is no mention of trucks and conveyors. Rule 58 to 60A of the Gujarat Factories Rules prescribe report forms for hoists and lifts (Form No. 9), lifting machines and tackles (Form No. 10) and further details thereof. The abstract of these statutory provisions is incorporated in the following paras.

3.1.2 Bombay Lift Act and Rules :

The Act : The Bombay Lift Act, 1939 has 14 Sections. It applies to the State of Maharashtra.

Section 3 includes definitions of lift, liftcar, lift installation, liftway and liftway enclosure. Here 'Lift' means a hoisting mechanism equipped with a car which moves in a substantially vertical direction, is worked by power and is designed to carry passengers or goods or both.

Sections 4 to 7A require permission to erect a lift, report of completion of erection, licence to use a lift and no operation, addition or alteration to the lift installation without previous permission.

Sections 8 & 8A give rights of Lift Inspector and Owner's duty to provide facilities for inspection.

Section 9 requires accident reporting to the Inspector of Lifts, Commissioner of Police or District

Magistrate, as soon as possible , no interference with the lift installation till inquiry and no re-start without the written permission.

Section II requires six monthly inspection by the inspector authorised. Section 12 gives rule making powers and Section 13 is a penalty provision.

The Rules : The Bombay Lift Rules, 1958 framed u/s 12 of the above Act, provide as under :

Rule 2 gives definitions of 54 terms.

Emergency Stop Switch means a device to cut off power to stop the lift car.

Safety Gear means a mechanical device attached to the car-frame or counter-weight to stop and to hold the lift-car or counter-weight to the guides in the event of free fall or if governor operated at over speed in the descending direction.

Slack Rope Switch means a device incorporating a switch used in a drum-driven lift for automatically cutting off the power in case all or any of the suspension ropes becomes slack.

Permission for installing lift or for making additions or alterations is necessary (R.3 and Form A). Licence for working lift necessary (R.4). It shall not be granted unless requirements laid down in the Schedule are complied with (R.5.). Terms for Licensee (R.6), Report of accidents in Form F within 24 hours (R.8), Unused lifts (R.9) etc. are some other rules.

Schedule u/r 5 gives the most important thirty technical items which include many safety devices. The lift-well for the fire lift, required for more than 24 mt height , shall be segregated by a brick masonry or RCC wall of a fire resistance of more than 2 hours. Minimum landing gate (door) size is 68 cm width and 2 mt height. Interlock devices for gates/doors should be of electro-mechanical type. A special key should be available to open the door in case of emergency. Minimum lift-car height 2 mt. Minimum thrust resistance 75 Ibs without deformation. Man weight criteria 68 Kg. Maximum load to be marked. Overloading prohibited. A push button alarm wired from electric mains other than the lift mains shall be provided. Emergency exit in the car roof necessary. Factor of safety of the combined suspension ropes shall be as under :

For rope speed upto	2 m/s	F.S. – 10
	3.5 m/s	F.S. – 11
	7 m/s	F.S. - 12

Chains are not allowed for suspension ropes. For drum drive two ropes and for traction drive three independent ropes are required for lift-car or counterweight.

More details are prescribed for lift-car safely gear and overspeed governor. The later is meant to retard the descending overspeed.

3.1.3 Gujarat Lifts and Escalator Act, 2000 and Rules 2001

For details, see Part 9 of Chapter 28.

3.2 Indian Standards :

There are many IS on material handling a few of which are : Material handling equipment, non powered, terminology 6839, Hoists and cranes, design, manufacture, erection and testing 807, Hoists and lifts, steel wire suspension ropes for 2365, Hoist chain, electric 6547, electric wire rope 3938, wire slings 12735, for hydraulic gates 6938, 10210, Ropes-coir 1410, 1411, 1412, cotton 2452, 2453, 3143, fibre 3871, 4575, guide 3623, jute 5177, manila 1084, nylon filament 4572, 6590, 3253, test methods 7071, polyethylene 8674, steel wire 1835, 5836, 2266, 3973, aerial ropeway and cable ways 7649, 5229, 5230, Single-chain, mild steel 2760, 8324, legs and wire rope 2762, fibre rope slings 9944, socket 2485, Shackle 4690. 6132, Swivels 4531, C-hook 3813, head nut 10749, Tackle 6549, 5529, Elevator 6930, 7167, Escalators 4591, Conveyors - glossary 4240, safety 7155, apron 7423, 8599, belt 6687, 8597, 8531, chain 7155, 6834, screw 5563, Electric passenger and goods lifts 1860, 3534, 6620, inspection of lift wire ropes 8216, Hand operated chain pulley blocks 3832, Portable mine hoist 11922, Round steel short link chain (electric butt welded) grade 30, 2429, grade 40, 3109, Gas cylinders safety devices 5903, colour code 5, handling 3870, Safety for handling cryogenic liquids (liquefied gases viz. 0,, N,, H,, Helium, argon, neon and krypton) 5931. Powered industrial trucks 6305, 7552, 7553, 7862, cable lift 4289, chain lifting safe use 8324, Gantry travelling crane 3177, for lifting air cargo 12462, winch 9507, wheel barrows 2431, 4814.

Safety nets 11057, Metal hooks, clips and eyes 4066, Crane, safe working loads 6511. Stability testing of forklift trucks 4357, Platform trucks 7361, 10311, Side loader trucks 9075, Powered tow trucks

10312, Safety Code for handling and storage of building materials 7969, Safety Code for scaffolds and ladders 3696.

Packaging code 10106, Pictorial markings for handling and labelling of goods 1260, Requirements for packing pesticides 8190.

IS :1860 Code of Practice for Installation, Operation and Maintenance of Electric Passenger and Goods Lifts is worth mentioning.

It includes 58 definitions (terminology) and essential requirements -like conformity with statutory provisions and IS, lift wells, lift pits, bottom and top clearance, well enclosures, lift cars, locking devices, suspension ropes, counter-weights, buffers, emergency safety device, safety gear tests, slack rope switch, automatic power cutting device, electric wiring and apparatus.

It gives design consideration of number of lifts and capacity, passenger lifts, goods lifts, hospital bed lifts, positioning of lifts, positioning of machine room, structural consideration, fire protection, quiet operation, supply cables and switches.

It also deals with testing, running, maintenance and general information to be given with inquiry and order.

These Indian Standards are very much useful for design, construction, use, operation and maintenance of lifting equipments.

3.3 General Requirements of Mechanical Handling:

Mechanical handling is defined as the movement of goods by mechanical force for the purpose of feeding, loading or unloading to or from a machine, plant or storage place, to or from a means of transport such as vehicles, ships or air transport.

The equipment employed may be powered by electromagnetic, hydraulic or pneumatic energy,

Main hazards of mechanical handling are contact with moving dangerous parts (pulley-belts, gears, in-running nips, couplings etc.), falling from the height or on the floor, striking against or struck by falling bodies.

3.3.1 Types & Uses :

Types of mechanical material handling equipment are classified in the beginning of this Part 3.

Factors affecting selection of means of handling and lifting are : Weight, shape, size, physical and chemical character, rate of handling, purpose and distance of moving, obstacles if any, structural condition of the floor, pathway and direction of movement.

Uses of the main mechanical handling equipment are given below :

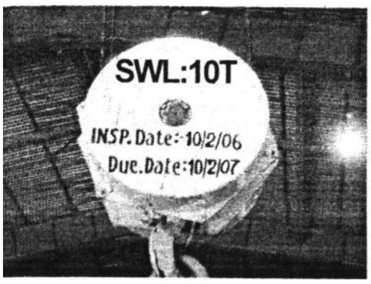
Equipment	Useful for
Electric Overhead Travelling crane (EOT)	Lifting, shifting and placing, anywhere in the traveling area.
Jib Crane (Mobile) Gantry crane	Lifting and shifting at desired places.
Power trucks	Three or four wheeler truck to pick, hold and carry (transport) material. Useful in making piles,

	stacking and unstacking.
Power trucks	Three or four wheeler truck to pick, hold and carry (transport) material. Useful in making piles, stacking and unstacking.
Conveyors	Transporting/Carrying material between two fixed points. Useful as a feeding device where manual feeding is unsafe. Workers should not ride on conveyors.
Lifting tackles	They are rings and slings (chain or rope, metal or fibre), hooks, shackles and swivels. They are used to connect load or container to nay lifting device.
For Lift Truck	It is a power truck having projecting fork to pick, hold, carry and unload (replace) the material or container. May be power driven or battery operated. Conveniently used on smooth floor.
Pay loaders, Power shovels, Winch crab, Pullers and Hydraulic/ Pneumatic jacks	Used to dig, lift and transport heavy material. Well trained operators, supervision and good maintenance are necessary.
Lifts and Elevators	Moves vertical, horizontal or in any unilateral direction (cable path) between two fixed points, lift vertically and carry material or persons. A cage or cabin must travel in a fixed path and well enclosed. Interlocked doors/gates necessary.
Hoists.	Hoists are of three types : Electric, pneumatic and hand operated chain hoists. Chain hoists are of three types - spur geared, differential and screw geared i.e. worm drive. The spur-geared type is most efficient Push-button cable must be supported by a chain to protect against strain.
Mono-rails	Should be well supported on both ends like a hanging bridge. The chain pulley block or hoist mounted on it should move freely. Stops must be provided at both the ends. Useful to lift load and carry horizontally between two fixed points.

3.3.2 Safe Working Load :

Safe Working Load (SWL) is the limiting safety factor to lift and carry any load safely. It must be clearly marked on any lifting device (hoists, lifts, lifting machines and tackles).

Section 28(l)(c) of the Factories Act, prescribes as under :



"The maximum safe working load shall be plainly marked on every hoist or lift, and no load greater than such load shall be carried thereon."

Section 29(1)(b) of the same Act, prescribes as under :

"No lifting machine and no chain, rope or lifting tackle shall, except for the purpose of test, be loaded beyond the safe working load which shall be plainly marked and duly entered in the prescribed register, and where this is not practicable, a table showing the safe working loads of every kind and size of lifting machine or chain, rope or lifting tackle in use shall be displayed in prominent positions on the premises."

Rule 60 of the Gujarat Factories Rules 1963 requires that:

1. The safe working load has to be specified by a competent person after thorough testing and examination.
2. Where the safe working load may be varied by the raising or lowering of the jib, a table indicating the SWL at corresponding indication of the jib or corresponding radii of .the load shall be attached with the jib-crane.
3. A table showing the SWL of every kind and size of chain, rope or lifting tackle in use, and in case of a multiple sling, the SWL at different angles of the legs, shall be posted in the store room.

Marking System of SWL :

Lifting equipment should have a tally plate indicating the SWL. The tally plate also indicates the identification number which can be mentioned in die test certificate held by the user. It should also indicate the date of last inspection.

Safe Working Load of different types of slings are given in the table below :

Safe working load in straight pull 	Choke 	Basket 0^{o} 	Basket 0-90^{o} 	Basket 120^{o} 	ELTECH SLINGS	COLOUR
Kg	Kg	Kg	Kg	Kg	Average Dia in mm	
1000	800	2000	1400	1000	18	VIOLET
2000	1600	4000	2800	2000	20	GREEN
3000	2400	6000	4200	3000	22	YELLOW
4000	3200	8000	5600	4000	25	GRAY
5000	4000	10000	7000	5000	27	RED
6000	4800	12000	8400	6000	32	BROWN
8000	6400	16000	11200	8000	38	BLUE
10000	8000	20000	14000	10000	46	L. GREEN
12000	9600	24000	16800	12000	58	GRAY
15000	12000	30000	21000	15000	70	ORANGE
20000	16000	40000	28000	20000	78	ORANGE
36000	28000	72000	50400	36000	114	ORANGE

Place of marking of SWL of different equipment is shown in the table below :

Type of Equipment	Place of Marking of SWL *
Lifting eye bolt	Side of the eye. Size and type of thread also be marked.
Shackles	On one leg SWL and on other leg identification mark and symbol are marked.
Chain Sling	On terminal fitting (ring) or on a separate idel link.
Multiple legged slings	SWL at 90^{o} angle is marked on upper terminal ring.

Wire ropes	A metal sleeve or tag with marking is attached.
Chains	Marking for quality of material on every 20^{th} link or 3 feet apart whichever is less. SWL on chain sling.
Hooks	SWL on one side of non vital part and on reverse side the identification mark.
* Where marking on the body part is not possible, it should be shown by tagging.	

Calculation of SWL:

$$SWL = \frac{\text{Minimum breaking load quoted by the manufacturer}}{\text{Factor of Safety}}$$

For wire ropes, FS is 6 for general purpose and 7 for heavy industry. A thumb rule formula is

SWL = $(\text{Wire rope dia})^2 \times 8$ kgs
viz. for 12 mm dia wire rope,
SWL = 12^2 x8= 1152 kgs

For slings, SWL depends on the length of the sling leg (L) and headroom between the hook and the load (H). Then for bridge hitch

SWL = SWL of single vertical hitch x H/L x 2
For double basket hitch,
SWL = SWL of single vertical hitch x H/L x 4

Tables showing the SWL of all slings at different angles of the legs shall be posted in prominent positions at work place.

For hoists, lifts, cranes etc., SWL is recommended by the manufacturer.

SWL of any mobile crane depends on operator's skill, condition of the ground, boom length, radius of rotation while lifting the load, -inclination of boom to the vertical and out rigger blocked or free.

SWL is generally tabulated in the load chart of the crane. Sometimes, it is de-rated (decreased) due to defects in welding, bend in angle, bracing etc. and condition of clutch, brake etc. Modern cranes give digital display of SWL and alarm for exceeding load.

Factor of safety of fibre ropes varies from 6 to 12 depending on conditions of use. Fibre rope less than 12 mm dia should not be used for a sling or a part of a lifting appliance. Their factor of safety (FS) varies with diameter. Factor of Safety for hook, wire rope sling, chain, fiber rope and belt are given in the table below:

No.	Item	Factor of Safety
1	Mild Steel Hook	5
2	High Tensile Steel Hook	5
3	Wire Rope Sling	6
4	Endless Wire Rope Sling	8
5	C Hook	5
6	Shank Hook (General Purpose)	5
7	C Hook with Eye (0.25 T)	4
8	Point Hook with Shank (63-160 T)	5

9	Hook (General Purpose 1-25 T)	4
10	Hook (General Purpose 25-100 T)	As per IS : 7847
11	Chain Gr. : 30	4
12	Chain Gr. : 40	4
13	Chain Gr. : 63	4
14	Chain Gr. : 80	4
15	Chain Sling	4
16	Eye Hook for Chain Sling	4
17	Synthetic Fiber Rope	
	Diameter	
	12 mm.	12
	14-17 mm.	10
	18-23 mm.	8
	24-29 mm.	7
	40 and above	6
18	Polyester Belt	7 (For belt)
		4 (For end fitting)

3.3.3 Proof Test:

Proof testing is the application of a load greater than the SWL to detect defective workmanship, faulty welds or other inherent weaknesses. It is not a means to assess the SWL which should only be done by calculations and checked where necessary by suitable tests on samples.

Proof test is required as a part of 'thorough examination' u/r 60(1) of GFR and no lifting machine or tackle should be used for the first time without this proof test.

In general the proof load applied to chains, rings, hooks, shackles and similar gear is twice the SWL. It should be just under the yield stress for the material.

The standard proof load for mild steel or wrought iron short link chain is as under :

Grade	Test load in Tons
Upto 30	$12\ d^2$
Upto 40	$16\ d^2$
Upto 60	$24\ d^2$
Upto 80	$32\ d^2$

Where 'd" is the diameter of the material from which the chain is made.

All items used in lifting machinery should be subjected to proof test loads as under :

Item	Proof Test Load
Chains, ring, hook, shackles, swivels, slings, individual components of hoists, wire rope, chain, pulleys, hooks, eye bolts, pins, axles, bearings, turn buckles & ringing screws.	2 SWL
Single sheave pulley blocks	4 SWL
Multiple sheave pulley blocks	
Up to 20 T	2 SWL
Up to 40 T	SWL + 20 T

Over 40 T	1.5 SWL
Electric Hoists, Cranes (Mobile & EOT)	
UP to 20 T	1.25 SWL
20 to 50 T	SWL + 5 T
Over 50 T	1.10 SWL
Endless Slings	4 SWL of single part
Derricks	1.25 SWL static & 1 SWL for all full movement.

After above proof examined thoroughly by signs of cracks, fatigue, stretch etc.

3.4 Lifts and Hoists :

The Factories Act requires as under

Every hoist and lift shall be of good mechanical construction, sound material and adequate strength, properly maintained and examined by a competent person at least once in every six months. Its report should be in Form No. 9, GFR.

Good construction means as per standards (e.g. IS). Sound material means as per required quality of the material. Adequate strength means proper design, factor of safety and good workmanship. Properly maintained means following safe and standard procedures, work permits, manufacturer's and other guidelines.

Every hoist or lift shall have the safe working load plainly marked on it and no load greater than such load should be carried on it. The cage of every hoist or lift used for carrying persons should be fitted with a gate on each side from which access is afforded to a landing and such gates should be fitted with interlocking or other efficient devices to ensure that they cannot be opened except when the cage is at the landing and the cage cannot be moved unless all the gates are closed.

Whenever the cage is supported by rope or chain, there shall be at least two ropes or chains separately connected with the cage and balance weight and each rope or chain with its attachments should be capable of carrying the whole weight of the cage together with the maximum load. Efficient devices should be provided and maintained capable of supporting the cage together with the maximum load in the event of breakage of the ropes, chains or attachments. There should also be an efficient automatic device to prevent the cage from overrunning.

Gujarat Lift Act and Rules provide more details. See Part 3.1.3.

See Rule 65 and 78 of the Building Workers Central Rules, 1998. (Part 7.2, Chapter-28).

Horsepower to lift a load is given by the following formula:

$$HP = \frac{L \times S}{450}$$

Where L = load in Ibs and S = speed of lift in ft/sec.

For example, if one ton load is to be lifted at 5 ft/sec, HP of an electric motor should be :

$$HP = \frac{2240 \text{ Ibs} \times 5 \text{ fl/sec}}{450} = 24.88 = 25$$

Similarly load on the line can also be determined. For example, when a 30 HP motor moves a drag bucket 60 ft in 10 seconds, the load on the line is

$$L = \frac{HP \times 550}{S} = \frac{30 \times 550 \times 10}{60} = 2750 \text{ lbs}$$

Here I HP = 550 foot-pounds per second are considered and not the figure of 450 which allows for friction losses.

Since an electric motor can deliver 50% overload for a short time, the maximum load on the above motor (and the lifting line) could reach 2750 x 1.5 = 4125 Ibs, if the drag bucket struck an obstruction.

3.4.1 Safety in Design, Construction and Operation :

General requirements are as under :

1. Hoist limit switch to cut of power and apply brakes when hook/cage rises to a predetermined level to prevent over-winding.
2. Limit switches to prevent over travelling and over transferring.
   These limit switches should automatically reset within a reasonable distance travelled in' the opposite direction.

3. Emergency push button for prompt use.
4. Isolation switch to cut off all power except lighting. Proper earthing.
5. Off position interlocking to prevent the circuit breaker from being closed unless all controllers are in off position.
6. Screen on bare conductors.
7. Pilot lamp (red lens) to indicate on or off condition.
8. Hand lamp of 25 volt DC or AC.
9. Earthing as per Electricity Rules.
10. Means of anchoring when the hoist/crane is left unattended or under storm conditions.
11. Others : Sheaves guard to retain ropes in grooves, safe means of access, ladders and guards on moving/rotating parts. Examination for wear, malfunction, damage and proper operation of hooks, ropes, brakes, clutches and limit switches.
12. Safety points for operation : No loading over SWL. Marking of SWL and load indicators for varying SWL. Pick up load only when it is directly under the hook, otherwise stresses will develop. Full vision in driver's cabin. Fire extinguishers, warning device, safe operating precautions for raising and lowering loads, moving loads over workers working underneath and duties of drivers while leaving the cabin, should be prescribed and followed. People should not be lifted or transported by hoist or crane.

Safety Aspects of Lifts or Elevators:

Following are the specific safety aspects for safe design and operation of lifts or elevators:

1. **Lift Wells :** No projection inside, sufficient space for repairs and maintenance, fire proof to the maximum extent.

2. **Lift Well Enclosures :** Enclosed construction, if wire mesh, opening should not be more than 32 mm. Clearance between moving car and the platform sill or wall shall not be more than 25 mm to avoid trapping.

3. **Lift Pit :** It should be waterproof to disallow water from outside.

4. **Top & Bottom Clearance :** Minimum I mt in the top and I mt in the bottom.

5. **Landing Gate & Doors :** Landing door should cover the full size of the car gate opening and if it is collapsible, grill opening should not be of more than 6 cms wide and if it is solid, it should have a vision panel of not more than 25 mm width. Solid door is safer.

6. **Interlocked Gates & Doors :** Lift car shall not, move until all landing doors are closed and they will not open till the car is moving, except by a special key. Automatic door-closures are useful.

7. **Lift Cars :** Enclosed type, smooth and non-slippery floor, alarm and push button, light, ventilation, plug-socket on car top to take power supply for maintenance work, factor of safety more than 5, marking of 'persons' capacity' (base 68 kg per person)

8. **Counter Weight :** Should be in a steel frame, secured by two tie rods to prevent fall and travel in rigid steel guide.

9. **Buffers :** Spring or hydraulic type, of adequate strength, on the pit floor to absorb shocks if the car falls.

10. **Suspension Ropes :** 3 independent ropes for traction drive and 2 ropes with drum drive each rope separately and independently fixed to car and counter-weight, ropes free from joints and factor of safety more than 12 based on static contact load + weight of car and accessories.

11. **Emergency Safety Device :** Safety gear Instantaneous type. Gradual Wedge clamp or Flexible guide clamp - to retard the speed if it exceeds I m/s and operating on both the guides.

12. **Over Speed Governor :** It prevents the car from falling or overspeeding downwards. If speed exceeds the normal design speed, the governor applies brakes on the car driving mechanism and also releases safety clamps against the guide rails to bring the car to a smooth sliding stop.

13. **Slack Rope Switch :** If the car is obstructed while descending and the rope becomes slack, this switch will stop the machine.

14. **Machine Room :** Height should be more than 2 m, space around m/c more than 60 cm, hand lamp provided and room locked with a key, with the authorised person.

15. **Machine Supports :** Supporting beams shall be of steel or RCC. The factor of safety shall be 5 for steel and 7 for RCC.

16. **Final Limit Switches :** Upper and lower ultimate switches to stop the car automatically within the top and bottom clearances independently of the normal operating device and the terminal limit switches.

For statutory provisions see Part 9 of Chapter 28.

3.4.2 Testing, Inspection and Maintenance:

Testing includes insulation tests for electric wiring. Test voltage should be DC (more than twice the rated voltage) and insulation resistance of each wiring circuit should be more than 2 m ohms.

Tests for satisfactory operation of each controller, switch, contactor, relay, interlocks, sequence of operation, protective devices. Tolerance on specified speeds at full load shall be within 10%.

Overload test by 125% of the working load. Proof (test) load may vary from 1.5 to 4 times of the SWL as mentioned in Part 3.3.3. Sample of wire ropes should be tested.

Periodic inspections to detect unsafe conditions, warn or damaged parts, wear and other defects in wire and fibre ropes, lifting gear, tyres etc. are necessary.

Gear wheels and pinions should be maintained in good condition, properly keyed and in their correct gear mesh. Gear wheels and pinions with broken teeth or cracked areas, rims or bosses should be discarded and replaced. The faces of all ratchets, jaw clutches, gear locks and collars should be kept in their correct relationship to ensure safety in use.

Repairs shall be carried out by 'permit to work' system. All power shall be disconnected while doing such work.

Notices like 'under repair' 'out of order' 'don't' . start' etc. shall be displayed.

3.4.3 Signalling :

Importance of proper signalling for co-operation between the hoist/crane operator and the slingers/ signallers or the motion indicators should be recognised, a code of practice should be developed and followed.

Signaller (hook-on person) should be thoroughly acquainted with the standard hand signals, the operation of the lifting equipment, the correct methods of securing, handling, stacking and piling loads and should be completely responsible for arranging slings or other hook-on devices and giving the signals that direct the equipment operator during the moving of the load.

The crane operator shall respond to signals only from the appointed (trained) signaller but shall obey a stop signal at any time from any body.

See fig. 15.1 for standard hand signals.

Refer rule 60 (8) the Gujarat Factories Rules.

3.5 Lifting Machines and Tackles :

Statutory provisions of Gujarat Factories Rules, Dock Workers Safety Rules and Building and Other Construction Workers Rules should be referred for details.

According to the Factories Rules, no lifting machines, chains, ropes and lifting tackles should be taken into use unless it has been tested and all parts have been thoroughly examined by a competent person and a certificate of such examination specifying the safe working load is obtained.

Also no lifting machine, chain, rope or lifting tackle should, except for the purpose of testing, be loaded beyond the safe working load. The safe working ' load shall be plainly marked on each such gear together with an identification mark and corresponding entries made in a register. Whenever these cannot be marked, a table showing the safe working loads of every kind and size of lifting machine, chain rope or lifting tackle in use should be displayed in prominent positions.

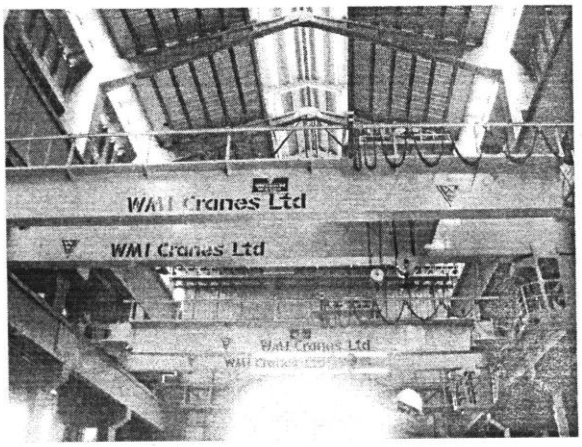
3.5.1 Types and Safety aspects of Lifting Machines :

Lifting machine means crane, puUy block, mono rail, crab, winch, derric etc.

Different types of cranes are available. Their selection depends upon type of use. Jib crane, pillar crane, climbing crane, overhead crane (manual or power driven), gantry crane, cantilever gantry crane, semi-gantry crane, hammerhead crane, wall crane etc.

Detailed safety rules for inspection, operation, signalling and maintenance should be available in writing, the operators should be trained for that and they should be strictly followed. Chapter-VII (R.55 to 81) of the Building & Construction Workers Rules is most relevant. See also Part 7.2 of Chapter-28.

Overhead Travelling Cranes : Electrically operated (power driven) overhead travelling cranes are known as EOT or OET cranes. Others are non-powered i.e. manually operated overhead travelling cranes. In the use of overhead cranes, great care should be taken for the safe and adequate means of access. It is necessary that all ladders and steps should be



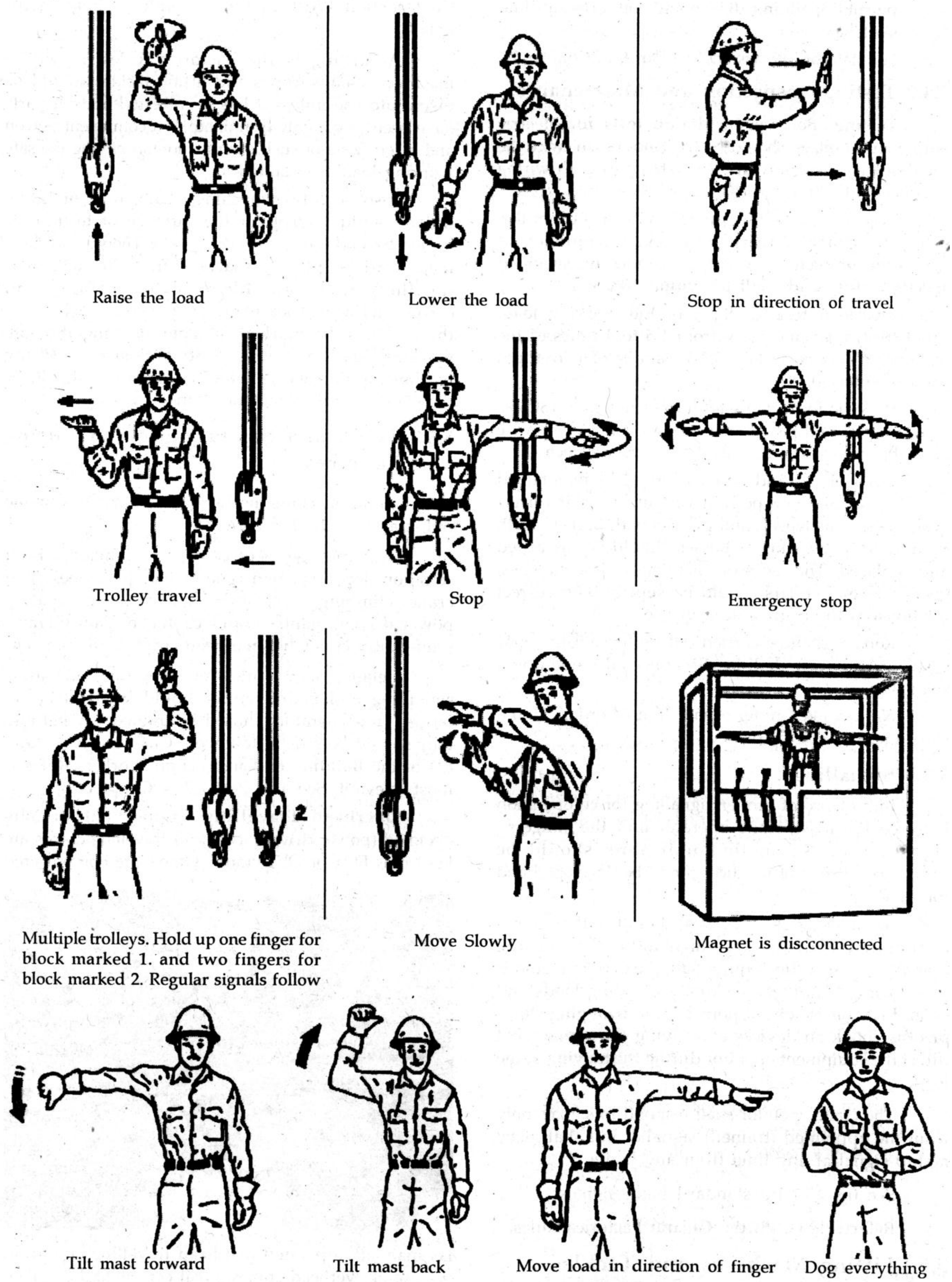


Fig. 15.1 Standard hand signals

provided with secure handholds and footholds. Stairways are preferable to ladders. Proper landing or stages should be provided at the point of transfer from ladder to the driver's cabin.

While any person is employed or is working on or near the wheel track of a travelling crane in any place where he would be liable to be struck by the crane, effective measures shall be taken to ensure that the crane docs not approach 6 m of the place. Effective means should be arranged to prevent a crane from travelling into the dangerous zone.

Passage way for crane : The passage (walk way) (= 50 cm width, toe board 10 cm) shall be provided at a lower level than the crane track and safe access ladders (width > 40 cm, double hand rails of 90 cm high) shall also be provided at suitable intervals to afford access to these passage ways and from passage ways to the rails track [Rule 60A GFR]. Vertical head clearance between the walkway and the overhead structure should be more than 2 m. Walkway surface should be non-slip type and without floor openings.

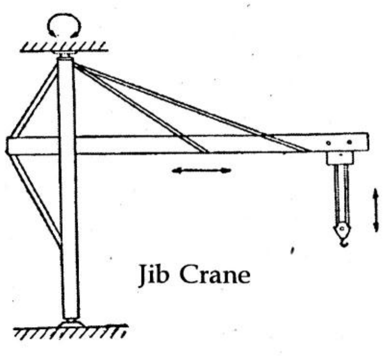
Rubber mat at the control panel in the cab is necessary to protect against electric shock. The cabdriver should have full view of the area of work. Rail alignment should be checked every year. Rail stops or bumpers should be so located that when contacted, the crane bridge remains right angle with the runway.

When not in use, a -crane should be' parked with hook raised at a safer height, all controls in off position and the main switch open.

Inspection and testing of heavy duty EOT crane include deflection test, over load test, operation test, insulation test, warning light test, earthing and bonding check, hoist and track limit switches check, proximity warning device check, braking and locking check, control gear check, guarding and weather protection, means of access, buffers and wire ropes of sufficient capacities. -All control mechanism, safety devices, leakage in air or hydraulic system, hooks and ropes, electrical apparatus, travel and steering devices should be properly checked. Preventive maintenance is most desirable. Moving parts should be regularly lubricated. A crane should not be left unattended. Crane operators must be fully trained for safe operations.

Deflection test must be carried out with the SWL M rest and with the crab in a central position. The deflection should not exceed 1/900 of the span.

Jib Cranes : A jib crane means a stationary or mobile crane in which suspension rope is supported by a projecting, horizontal or inclined member known as a jib. Jib crane can lift, lower and rotate the load within the circular arc covered by a rotating arm or jib.


Jib Crane

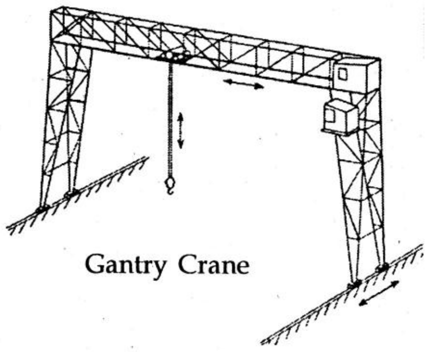
It is important that capacity of the jib crane clearly showing the maximum safe working load for the various inclination of the jib or various positions of the trolley on horizontal jib should be marked on the sides of the jib or on the mast or on the pillars.

A number o accidents have occurred due to overloading of jib cranes. It should be fitted with automatic indicators which will give efficient sound signals whenever the load moved is in excess of the safe working load.

Structure (floor, wall or column) should be checked for its strength before mounting a jib crane. The jib should be guyed or braced to withstand heavy load.

A stop plate (bumper) at the end of the jib is necessary to prevent the load trolley from running oft the beam. It should be frequently checked.

Bridge and Gantry Cranes : These are similar to travelling cranes except that they run on rails at ground level instead of on elevated runway girders. Gantry cranes have short spans, while bridge cranes may have spans upto 100 m or more. Bridge cranes are usually used for handling coal or ore. Sweep guards on nip between rail and wheels, rail clamps and brakes to prevent movement due to high wind, safe height of electric contact rails, operator's cabin to be fireproof and weatherproof, I m side clearance with the truck wheels of gantry cranes, skew switches to prevent excessive distortion of the bridge etc., are some .of the safety measures.


Gantry Crane

A sounding device (gong) should always warn when the crane is moving. The bumpers should be of cast steel plates or spring type. Floor or foot-walk should have drainage, a handrail and toe board up to entrance landing. A rope ladder in the cab for emergency escape and locking ratchets on wheel locks, rail clamps and brakes to secure against high wind etc. are necessary.

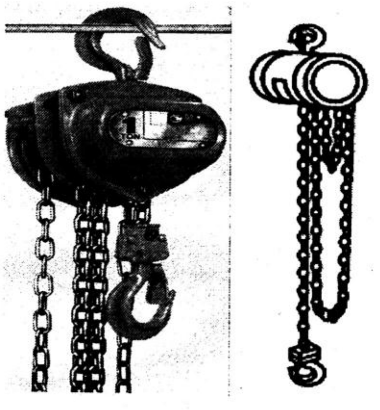
General requirement for all crane equipment are : good construction, sound material, adequate strength and free from patent defect. It should be regularly inspected and properly used. Statutory provisions must be followed.

Design safety measures should include over-travel limit switches, protection of bare conductors, controls to prevent inadvertent operation, load indicators (audio-visual automatic excess load indicator), safety catches, emergency escape, operating position and marking of SWL.

Safe operating techniques must be taught to the operator.

Lifting accessories - chain, wire rope or fibre rope slings, eyebolts, shackles and special lifting equipment must be of good construction, sufficient strength, properly designed and heat-treated as per requirement.

See Rule 80 of the Building Workers Central Rules 1998 for 'Tower Cranes'.



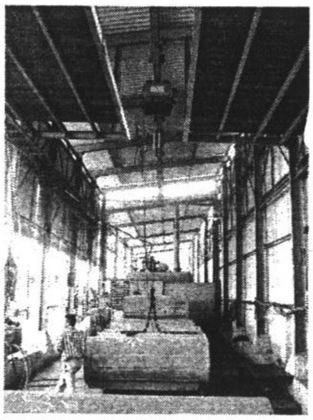
Pulley-blocks or Chain Hoists : These are spur geared, screw geared and differential chain hoists. They may be portable, portable but permanently hooked onto a monorail trolley or built into the trolley as an integral part. They are suitable for many operations on which a block and tackle fitted with manila rope is used and are stronger and more dependable than rope tackle.

The spur geared type is the most efficient. Screw-geared and differential hoists are self-locking to automatically hold a load in position. Load carrying parts should be made of steel. The load safety factor of chains should be more than 5. It should be more than 10 for manila rope.

While using pulley block in confined spaces, the whole block or the rope or wire nip should be guarded.

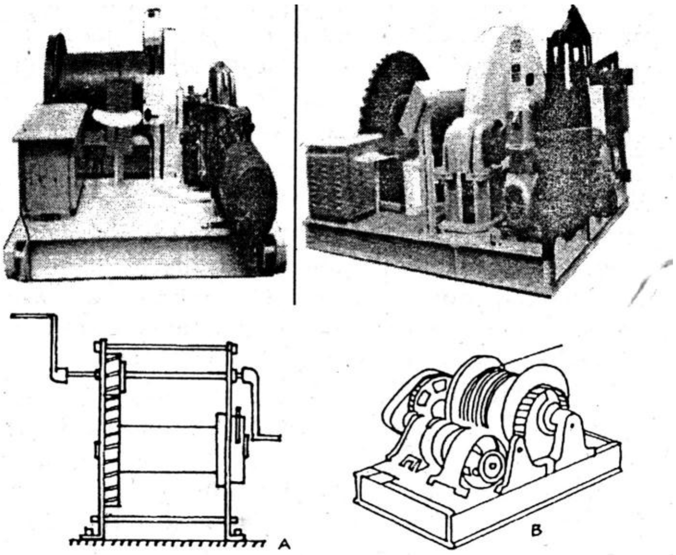
The safe working load should be plainly marked on the block and it should be tested every year. All parts subject to wear should be frequently examined.

See Rule 60 and Form (test report) 10 under the Gujarat Factories Rules and Schedule I and Forms VI to X under the Building and other Construction Workers (Central) Rules 1998.



Monorails : This system consists of one or more independent trolleys supported from or within an overhead track from which hoists are suspended. Monorail hoists are used to raise, lower and transport materials. They are of three types - hand operated, semi hand operated and fully power operated. Rail stops at the ends of monorail tracks are desirable. Tracks and their supports must be checked for strength and smooth running.

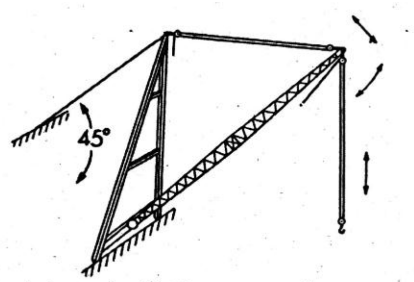
Crabs and Winches : They may be hand operated or electrically driven. Portable crabs and



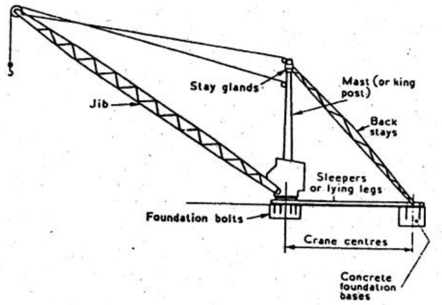
winches must be securely anchored against the pull of the hoisting rope or chain. A dog to lock the gears and a brake or safety lowering devices, crank-pin, lever on pawl and gear guards are necessary. Barricade guards are necessary to protect the operator against breaking wire and recoil of broken ropes.

See Rule 59 & 81 of the Building Workers Central Rules, 1998.

Derricks: Main types are the stiff-leg, A-frame, guy, ginpole and the breast derrick. With all derricks,



A frame derrick. Brace set at 45° to the



Derrick Crane mounted on Concrete Blocks

every part should be firmly anchored. Striking from mast, boom, sill, pulley block and swivel hook should be prevented. The hoist engine should be firmly tightened with the base to prevent its pull out. Derrick foot must be firmly supported. For safe rigging of derrick and its gear, rigging plans should be available.

See Part 4.1 of Chapter-22 for further details.

Hazards and Precautions of Remote operated Lifting Machines:

They are as under :

Hazards:

1. As directions (EWNS) are mentioned on the remote, operator is likely to be confused.
2. Chances of accidents in case of wrong movement of direction are possible.
3. As the operator is operating from the ground, his attention is deviated by the co-worker resulting in accident.
4. Person not trained in crane operation also tends to operate the crane, as remote (pendant) is easily accessible.
5. In case the "Push Button" or lever gear is pressed by mistake, crane motion may start automatically.
6. Operator may lock the motion by mechanical means in order to avoid holding by operating the push button/lever.
7. Motion of the crane is activated by radio frequency. Interference by other radio frequency may move the crane automatically and cause dangerous situation. 8 In case of emergency, main switch is not easily accessible. Main switch of DSL may be far away.

Advantages:

1. Operator is not required to climb on the lifting machine.
2. Operator can operate the crane close to the load; this gives more accuracy and precision in handling.
3. Communication between operator and attendant (slinger) is better. Hand signaling may not be required, verbal communication is possible.
4. Operation of crane is easier.
5. For smaller lifting, the work of slinger (attendant) may be carried out by operator himself.

6. Attendant (slinger) or any other person can easily be trained for crane operation.
7. No chance of electrical shock as it is completely isolated from high voltage.

Disadvantages:

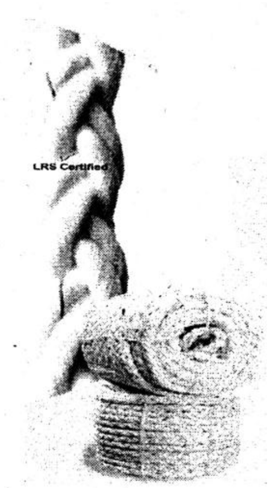
1 As the remote works on radio frequency operator may operate the crane from any place. He may not be moving close with the load.
2 Crane remains unattended, as operator is not close to the crane. Any abnormality like noise, vibration, loose part, lubrication, is not noticed regularly.
3 Maintenance person or operator is required to check the crane separately, regular (daily) inspection by operator may not be possible.
4 In case of operating from ground, the operator doesn't get the overall view of complete scene, e.g. obstruction in the part of a moving crane.
5 Main switch in the control cabin is not accessible.
6 Licence is required for radio frequency used for remote control.

3.5.2. Types and Safety aspects of Lifting Tackles :

Lifting tackles, gear or appliance means fibre rope slings, wire rope slings, chain slings, hooks, rings, sheaves (grooved pulleys), swivel, shackles and similar gears.

Ropes : Generally manila and sisal ropes are used in hoisting, lowering and handling operations. There are various grades of ropes and therefore while purchasing, their guaranteed breaking strength should be obtained from the manufacturer in order to assess the safe working loads of the ropes.

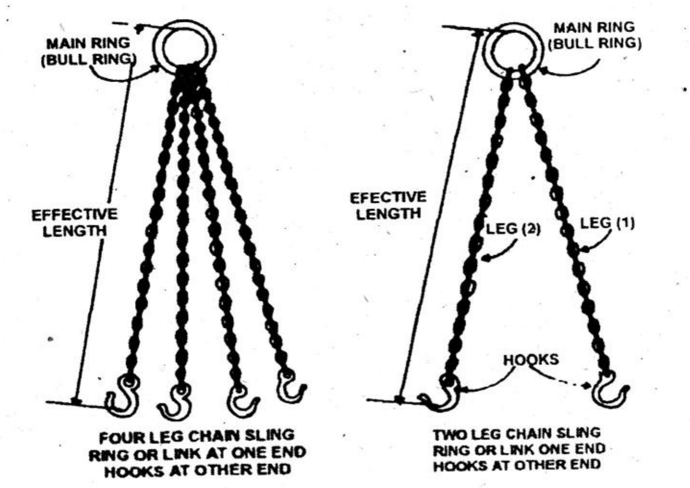
Fibre ropes are very susceptible to mechanical damage and they should therefore be frequently inspected for their strength. Particular care is necessary when it is suspected that the rope may have been contaminated by chemical action.



Fibre rope of less than 12 mm dia should not be used for a sling or a lifting device. For ropes, safe working load can be calculated by dividing the minimum breaking load quoted by the manufacturer by factor of safety depending on the use. For SWL and factor of safety see Part 3.3.2.

Periodical inspection of the whole length of rope is necessary to detect broken wires, amount of wear, corrosion, rust etc. Broken wires in a rope must always be regarded as a warning sign. Wire ropes must not be knotted. They should be joined solacing.

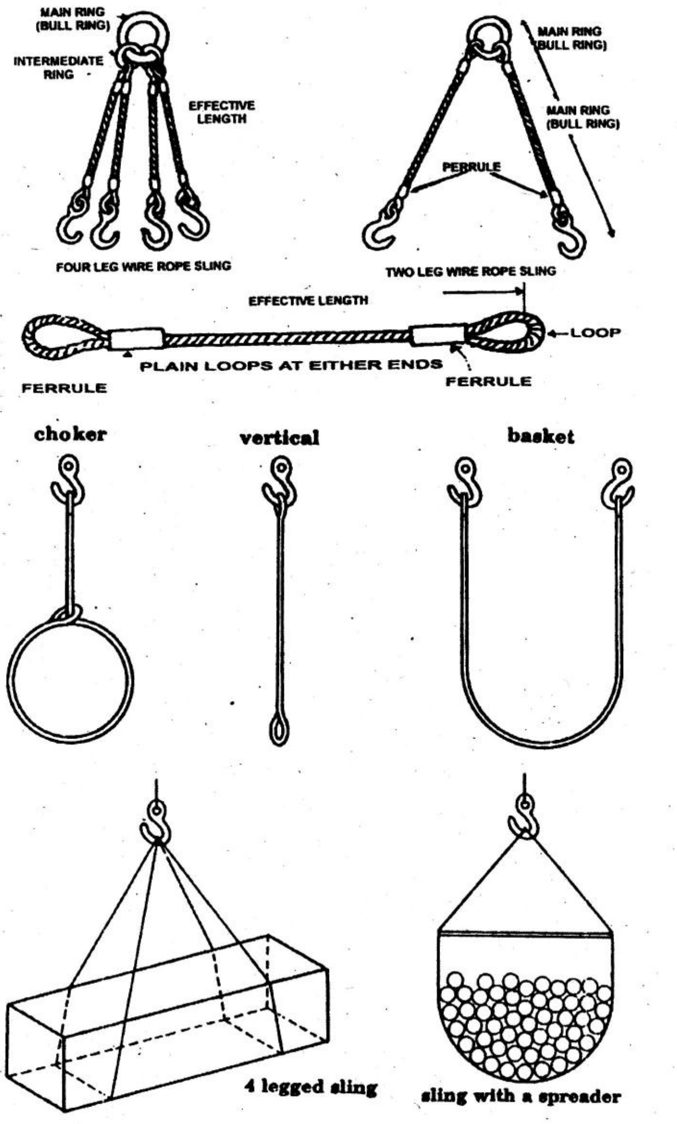
For the same working load, the chain sling is 5 to 8 times as heavy as wire rope but it has a longer life, stands up better-rough use and is almost 100% flexible. The chain is obtainable in many grades viz. wrought iron, mild steel, high tensile steel and alloy steel. Wrought chains require to be periodically heat treated to remove brittleness.



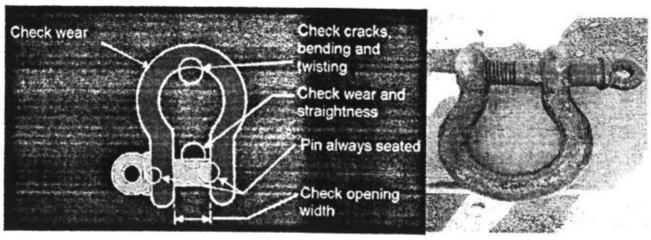
the number of legs. For example, when a 2 ton load is lifted by directly booking to the chain or cable, the load on the line is 2 tons. But if it is hooked to a two-legged sling, the leg of each sling carries I ton (while the line connected to the sling holds 2 tons). If ifs a four-legged sling, each leg carries 0.5 ton.

The stress in any leg increases as the angle of tile leg with t1ie horizontal decreases. In the two-legged sling, each leg carries a stress equal to the total load when the angle is 30°, and a stress of nearly six times the load when the angle is 5°. Therefore it is important to keep the angle as large as possible and the stresses be computed carefully to maintain a reasonable safety factor.

While using a sling, the ratio of the load lifted by any leg of the sling is inversely proportional to **Hook** is either of a circular section oi trapezoidal. The former is meant for light loads up to 5 tons. See part 2.5 for figures.



Shackles according to difference in shapes are known respectively as D and Bow shackles. The pins are usually of circular section. The methods of securing



'D' shackle Bow shackle

shackle pins in position vary according to the nature of the use of the shackles. When there is a risk of the pin coming out, pins are secured by means of a nut and a cotter pin. A cotter pin affords more rigidity than a plain pin.

All slings, rings, hooks, shackles, swivels, couplings, sockets etc., should be as per Indian Standards. Permissible working load of one leg should be calculated from the ready table of sling diameter and varying angles between two legs.

Plate lifting clamps are shown in fig. 15.2. They are attached to rings or/and slings. They must be properly tightened so that in lifting condition plate or load should not slip or fall.

All tackles should be thoroughly checked before use.

3.5.3 Safety in Design, Construction and Operation of Lifting Machines and Tackles :

The main requirements are as under :

1. Section 29 of the Factories Act and Rule 60 of the Gujarat Factories Rules require that (1) All parts including the working gear, whether fixed or movable, shall be of good construction, sound material, adequate strength and free from defects, properly maintained and thoroughly examined by a competent person at least once in a year (2) A travelling crane should not be moved within 6 m of any person where he would be liable to be struck by the crane and (3) All rails and tracks shall be of proper size, adequate strength, even running surface, properly laid and maintained and adequately supported.
2. Safe working load (SWL) and distinguishing or identification number should be marked on each lifting gear. A table of varying load and angle should be attached.
3. Heat treatment of lifting gear should be carried out to remove defective structure developed during forging, welding or service and to improve the properties of the material i.e. to increase its strength, hardness, ductility and toughness.

   Rule 60(5), GFR, requires annealing of parts in general use at least once in a year and that of the parts used to lift molten metal or slag or if made of less than 12.7 mm dia, once in 6 months.

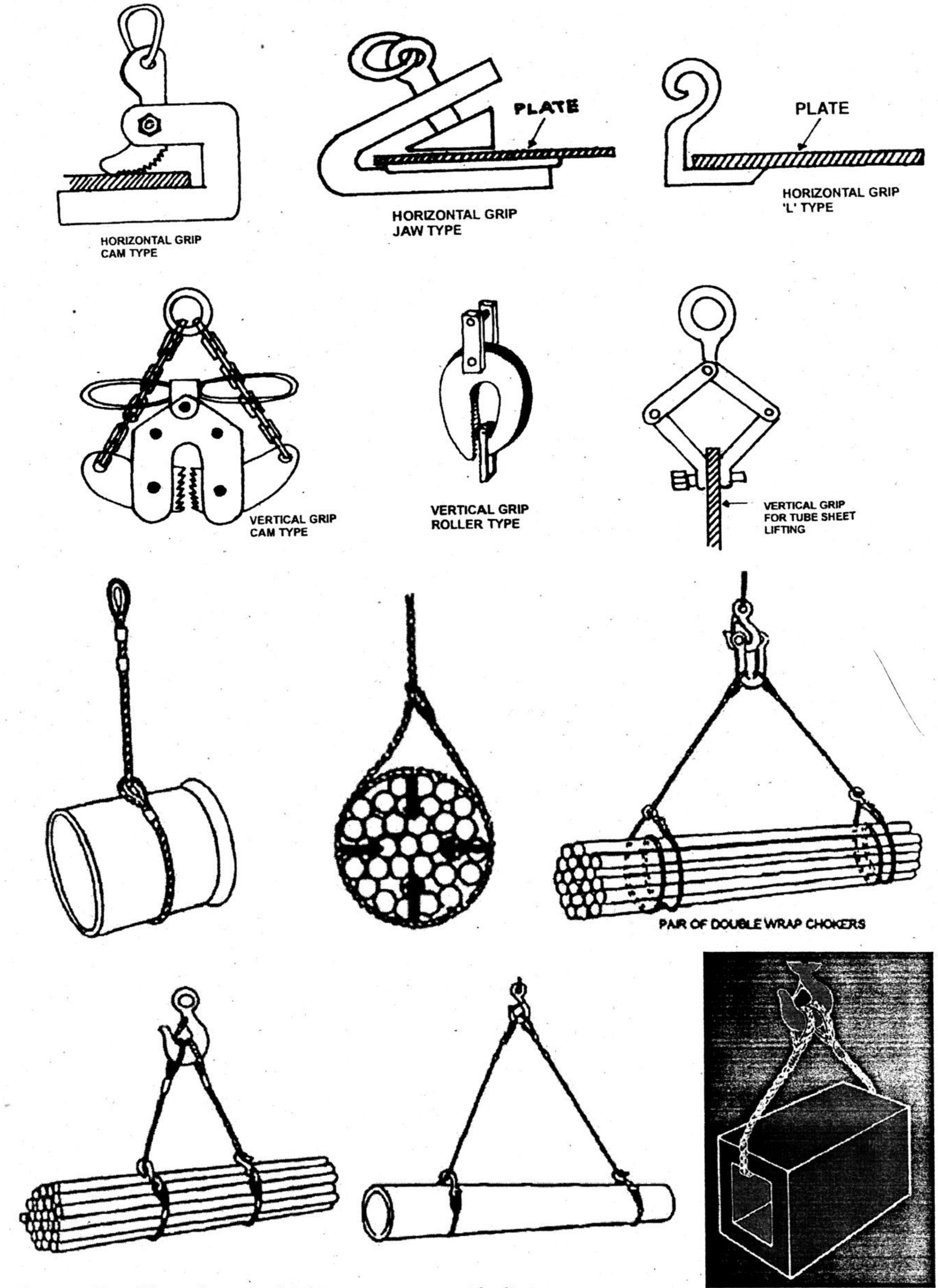


Fig. 15.2. Plate lifting clamps and Lifting arrangement with slings.

4. Chain slings should be selected as per the load requirement. Never decrease the angle between the legs of the chain sling and the horizontal. This will increase load in the sling legs. Pad sharp corners. Lift without jerk. Keep hands and fingers out of the chain and the load. Stand clear of the load when it is being lifted. Don't lift beyond SWL and employ trained personnel.
5. Wire rope is preferable than fibre rope due to its greater strength and durability, no change in physical characteristics and predictable stretch characteristics.
6. There are five basic design elements of a wire rope : Grade of wire. Number and pattern of wires in the strand. Type of lay. Performing and Type of core. Knowledge of these characteristics is useful in selection of wire rope or wire rope slings.
7. The diameter of the pulleys, reels, drums should be large to reduce bending action on the rope.
8. Parts subjected to impact, wear and rough use should be of sufficient strength for its rated service. Bearing pressure of shafts should be within safe limits.
9. Open hooks are unsafe. Spring lock at hook point and guard on load block pulley rope are desirable. Heavy hook should have handle to guide it for slings.
10. Gantry cranes should have rail clamps, parking brakes and wind velocity indicator and alarm.
11. Rated load should be marked on each side of the crane and on each load block (hook assembly) in case of more hoisting units on one crane. The crane shall not be loaded beyond its rated capacity except for testing.
12. Operating levers and control should be within reach of the operator. They should have 'spring returns' to move automatically to 'off position.
13. Platforms, footwalks, steps, hand holds, guard-rails and toe guards shall be provided for safe walking and access ways. Platforms should have non-slip surface. Step gap should not exceed 30 cm.
14. Positive stops or limit switches shall be provided to prevent overrunning the safe limits. Lower and upper travel limit switches should be provided.
15. Lubrication points shall be in safe position.
16. All gears, moving parts, couplings and rope neaps should be totally enclosed.
17. Travelling cranes should have powered and non-powered warning bells. Independent brakes for ' hoisting, traversing, travelling and parking operations.
18. Sheaves and drums should be inspected for wear. Enlarged grooves indicate replacement.
19. The rope end should be firmly anchored to the drum by a socket arrangement and minimum two turns (wraps) of rope should remain on the drum when the hook is at the lowest level.
20. The rated load divided by the number of rope parts should be less than 20% of the nominal breaking strength of the rope.
21. Power shall be shut off and personal padlock or tagging shall be provided before starting any repair or maintenance work. Arrangement should be made to prevent entry of another crane in the zone of crane under repair.
22. DCP, CO, or equivalent fire extinguisher should be kept in crane cabin.

3.5.4 Care, Testing, Inspection and Maintenance of Lifting Machines and Tackles :

Care in design, operation and maintenance of any lifting equipment is utmost necessary. It includes many points some of which are common and some specific points differ with the type of machine.

Some Common Points of Care :

Design	Operation	Maintenance
Appropriate factor of safety. Sound material & Good const.	Trained operator. No loading above SWL. Moving hook load	Periodical tests and certification. Lubrication of parts. Repairs and

Safe design. Marking of SWL & identification. Provision of limit switches, brakes, anchoring, earthing, guarding, means of access, ladders etc.	safely. Use signaling & warning. Raise or lower carefully. Following manufcturer's instruction. Work on or near tracks. No load handling over workers on floor. Safe position at the end of work.	replacement of parts. Daily and periodical inspection. Display of notices and load tables.

Some specific points are mentioned below :

Hoists & Lifts : DOS and Don'ts of safe operation should be followed. Safety devices and interlocking should be well maintained. Regular testing' and examination are necessary.

Lifting tackle or gear : If more than 10% wires are found broken or wear on any stress bearing part exceeds 10% of the requisite nominal dimension or the part shows signs of excessive wear, corrosion or other defects, it should be considered unfit for service.

Testing period of lifting machinery and tackles, prescribed by the Factories Act is one year. A test certificate specifying the SWL is also necessary (Rule 60, Form 10, GFR)

Metallurgical Defects and Heat Treatments :

Ferrous and non-ferrous metals are used to make lifting gear. Monel metal (2/3 nickel, 1/3 copper, small percentage of manganese and iron) is highly resistant to corrosion. Chains and other lifting gear made of monel metal are suitable for use in chemical plants.

Copper is the main constituent in brasses and bronzes. They are mainly used for bearings .in lifting gear.

Aluminium and manganese bronzes have high strength, ductility and corrosion resistance. They are used to make chains and fittings where higher corrosion resistance is required.

During welding process, the adjacent material is subjected to intense local heat and becomes brittle on cooling. Links, rings and chains require heat treatment to correct this coarse structure.

In the process of forging, drop forging steel is highly heated to have desired shape. Then the structure becomes brittle. With hammering or hot work the grain size in the material changes.

Defects are also developed during service. Due to interlink pounding, wrought iron develops surface brittleness. Due to bending strain, link becomes hardened and develops crack. Over a period it results in link fracture.

Internal hardness can develop both in wrought iron and steel gear due to overloading. Improper use causes reduction in ductility. Certain low carbon steels are liable to strain-ageing.

Rings, hooks, links etc. used in a sling must be of the same material and of equal strength as the chain.

Heat treatment (a series of operations involving heating and cooling of metal parts) - Low temperature annealing, normalising, hardening and tempering should be carried out as per requirement.

Heat treatment like normalising or hardening and tempering can restore the strained parts to. original condition provided no crack has taken place. Types of heat treatment are - low temperature annealing, normalising, hardening and tempering. Thus such metallurgical defects should be detected by proper inspection and necessary heat treatment be applied.

Defects and Precautions : Stretch or deformation, excessive wear, cracks, nicks, gouges and corrosion pits- should be searched by proper inspection procedure and removed.

Selection of proper rope and inspection before use are important. Workers should be thoroughly instructed to follow safe operating procedure in using ropes and chain slings. They should be kept away from heat, fumes, chemicals and exhaust gases. They should not be used against sharp edges. Protect them by padding. Observe proper slinging rules. Do not exceed safe slinging angles. Check for friction heating for fibre ropes.

No tackle should be dropped from heights. They should be stored in clean dry place.

Inspection of Tackles:

Normal inspection periods are as under:

Device	Period
Hoisting and lowering wire rope	3 months
Wire ropes with broken wire	1 month
Cranes and attachments	12 months
Thorough inspection of all parts of crane	3 years
All other lifting machinery	12 months
Half inch and smaller gear	6 months

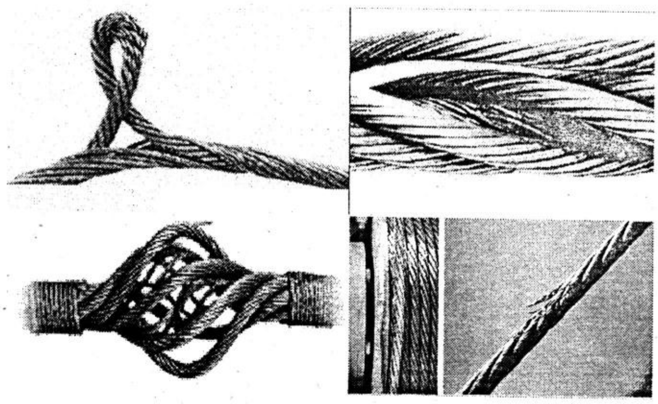
All items used in lifting machinery should be subjected to proof test loads (see Part 3.3.3) and after the test, they should be thoroughly examined by a competent person for signs of cracks, fatigue, deformation, stretch etc.

Hooks must be removed from service if they have opened outmore than 15% of the normal throat opening, measured at the narrowest point or twisted more than 10 degrees from the original plane of the hook. The bent hook should not be straightened and reused.

A locking pawl prevents the load to come out from the hook.

Fibre ropes should be inspected before use every time. Broken fibres, yarns, cuts, nicks, abrasion, unlaying and reduction in diameter are the main defects. If the fibres pulled from the rope breaks, it shows brittleness and need to replace the rope.

Wire ropes should be inspected for broken wires, torn, flattened and abraded wires, reduction in rope diameter, rope stretch, corrosion, kinks, crushed or jammed strands, bird caging and inadequate splices



New lubricants, free of grit should be applied on wire rope to penetrate internally as well as to coat the external surface.

Defects in wire ropes are : broken wires, worn and abraded wires, reduction in rope diameter, rope stretch, corrosion, kinks, crushed, flattened or jammed strands, bird caging and damaged splices. In such cases new wire rope should be used.

The visible broken wires should not be more than 5% of the total wires in a length of 10 rope diameter. Wear on the surface of the rope should not be more than 1/3 of the diameter of the wire. In pendants or stranding ropes, there should not be more than 3 broken wires in one rope lay.

Rope stretch should not be more than 15 cm per 30 m length in the six strand wire ropes. Rope should be discarded if more than 20 breaks appear on a rope lay.

Reduction in diameter of the rope due to core failure, abrasion etc. should not be more than
1.0 mm for ropes upto 19 mm dia
1.5 mm for ropes of 22 to 28 mm dia
2.0 mm for ropes of 32 to 38 mm dia

Chains : Most of the causes of chain failures can be detected before they occur if proper procedure is followed. Frequency of such inspections depends on service conditions. Normal defects are (1) stretch or deformation (2) excessive wear (3) cracks (4) nicks and gouges and (5) corrosion pits.

Chains are to be checked for crack, corrosion and pitting. More than 10% wear at their two-link-touching point render them unfit for use. Avoid jerks and impact loads. Never re-weld alloy chain links. Avoid crossing, twisting, kinking or knotting a chain.

Causes of chain failure are defective welds, defective metal and overloading. All chains should be thoroughly inspected link by link by a competent person. After shock or impact loads, it must be immediately inspected. It is an unsafe method to use the broken chain by inserting a bolt between two links.

Clean the chain thoroughly in a solvent solution. Lay it on a clean surface. Use magnifying glass to look for stretched links, wear, crack, corrosion and pitting, bent, twisted or damaged links. If stretch (elongation) is more than 3% the chain should be discarded. Elongation should be measured between fixed length of 10 or 20 links.

When the dia of the link is reduced due to wear and tear, SWL shall be reduced as under :

Normal chain link dia (mm)	**When the dia at worn section is as under (mm), reduce rated capacity by**	**Remove from service when dia**

	5%	10%	(mm) is or lower
6	5.75	5.70	5.40
9	8.78	8.55	8.10
13	12.68	12.35	11.70
16	15.60	15.20	14.40
19	18.53	18.05	17.10
22	21.45	20.45	19.80
25	24.38	23.38	22.50

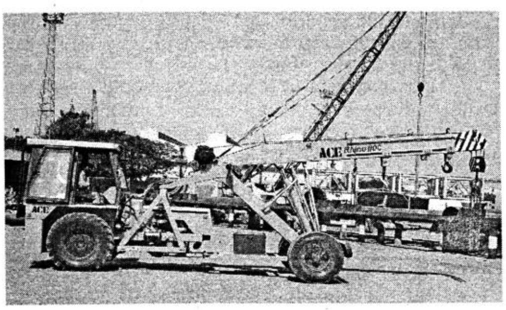
Shackles worn more than 10% of the original diameter in crown or the pin should be replaced. Pins should not be bent. Shackles shall not be pulled at an angle because it will reduce its capacity.

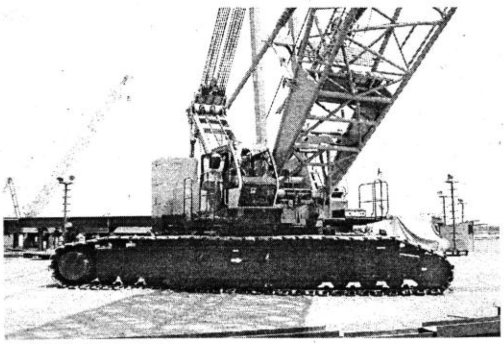
Chain pulley blocks of proper lifting capacity should only be used. They should be lubricated before every use. No alteration should be done on chain blocks. They should be tested for slip by suspending safe load. The chain should not come out of pulleys. The anchorage should be strong and rigid. Opened out hooks should not be used. Chain block/puller must be checked if stored for a long time, by subjecting to shock load, to observe slipping of load, jamming on links etc.

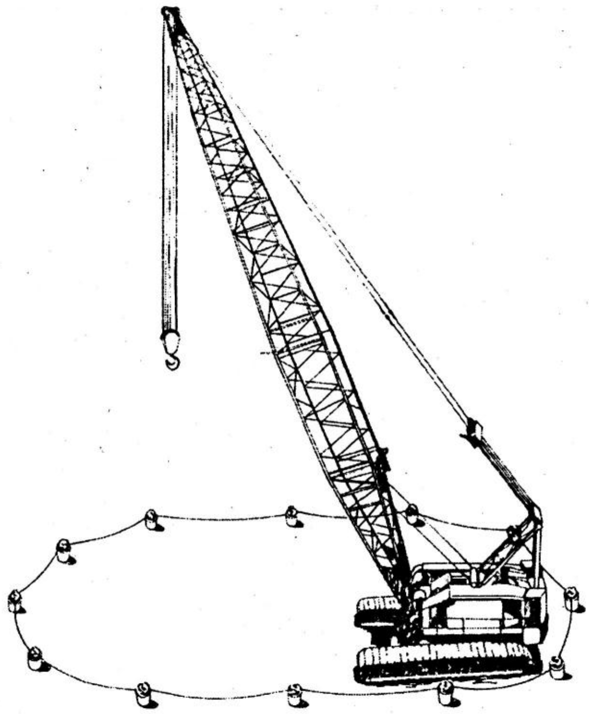
Winches should be placed on a firm base and properly anchored. Brake, ratchet arrangement, gear and pinion including meshing, wire rope and its clamping arrangement, direction of receiving rope drum and tie rods should be checked before using any winch.

Derrick - The mast, guy-ropes, wire ropes, swivel hook, rope clamps etc. should be thoroughly checked before erecting the derrick. Its lifting capacity should be ascertained by a competent person and it should not be overloaded. Guys of the derrick should be anchored tightly with strong structures, hold fasts, anchorage blocks etc. Welded parts should 'be periodically checked for any crack or defects in metal itself.

Mobile Cranes should not be used on a slope unless adequate precautions are taken to ensure stability.







SWL of cranes apply only when they are installed on a level, firm and uniform surface. Crane stability is reduced when operating on a slope. Therefore level must first be checked. It is dangerous to lift a load with 2 cranes and should be avoided unless a single crane of the required capacity is unavoidable. Trapping or striking with persons should be avoided. A crane should not be left unattended.

Jib or boom of a mobile crane should not touch any electric wire or loose construction which may fall. When any overhead material handling work is going on, simultaneous work down below must be avoided to eliminate risk of being hurt by any falling material.

Mobile cranes should be parked on hard soil or strong base. Tag lines should be used while hoisting heavy and bulky materials. The brakes, boom, hook, wire ropes, pulleys and rope anchoring should be checked periodically by a maintenance man to ensure the safe operation. Required derating should be done in case of any defects found and it should be formally made known to all concerned.

In case of a mobile crane, the load shall be derrick out while going up a gradient and the load shall be derrick into the minimum radius while going down:

Mobile cranes are to be tested for (1) A dynamic test of 10% overload (2) Test with 25% overload and (3) Static stability test.

All control mechanism, safety devices, hydraulic system, hooks, running ropes and electrical apparatus of a crane should be inspected frequently for malfunction, wear, deformation crack, fluid leak, dirt and moist accumulation etc.

Defects to be checked in a crane are

1. Deformed, cracked or corroded members of crane, structure and jib.
2. Loose bolts or rivets.
3. Cracked or worn sheaves and drums.
4. Worn or damaged pins, bearings, shafts, gears, rollers etc.

5. Excessive wear on brakes or clutch parts, linings, panels and ratchets.
6. Diesel, electric or other power units for improper performance.
7. Excessive wear on chain drive, sprocket and excessive chain stretch.
8. Travel, steering, braking and locking devices for malfunction and
9. Excessively worn or damaged tyres.

During repair and maintenance, permit to work system should be followed. A preventive maintenance programme, based on the crane manufacturer's recommendations should be established.

All moving parts should be regularly lubricated and lubricant level should be checked.

Crane operators should be of more than 18 years age and properly trained, medically fit with regard to eye sight, hearing and reflexes, and understand fully the duties of die slingers and be familiar with the signal code.

Documentation for record of inspection and maintenance and test certificates is equally important.

3.5.5 Safe Location :

Safe location or storage of lifting tackles is necessary.

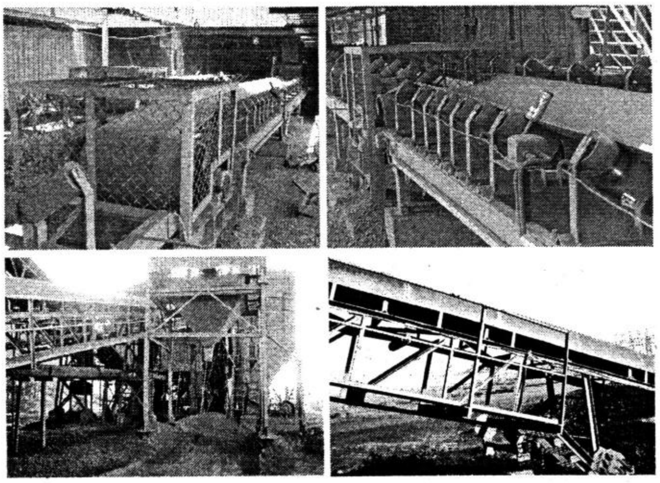
Proper storage of chains will impress the workers the need for proper care at: all times. The chains should be hung on racks in dry air and normal temperature to prevent rusting. Racks should be so arranged that no worker should be exposed to lifting hazards. Heavy chains may be stored in neat piles on a rack surface. Dampness, darkness and corrosive atmosphere should be avoided.

Slings should be kept on suitable racks or pegs when not in use. SWL should not be exceeded as a result of the angle between the legs.

Store the ropes in a cool, dry room having good air circulation. Hung the ropes up in loose coiled in pegs. Clean the rope after use and dry them before storing. Fibre ropes should be protected from pests, rats, sun, weather and dampness.

3.6 Conveyors & their Safety Features:

For moving material, normally two types of equipment are used. Conveyors are used when the path is fixed and industrial trucks are used when the path is free.



Various types of conveyors and mono-rail systems are used in many industries to eliminate manual labour, to expedite the movement of materials and also to facilitate the processing or assembling. Belt conveyors are widely used and they are of flat or trough type and can be horizontal or inclined. They are used for handling almost all the materials of modern industry including coal, coke, grain, fertilisers and building materials such as sand and gravel. Some important safety measures are :

1. Conveyors shall be so constructed and installed as to avoid hazardous points between moving and stationary parts or objects. Gears, sheaves, sprockets and all moveable parts shall be securely guarded.
2. Where workers have to cross over conveyors, regular crossing facilities affording safe passage and adequate lighting shall be provided. To cross underneath, at least 7 feet headroom is required. Crossovers should be with bridge, stairs and handrails.
3. Conveyors shall be provided at loading and unloading stations and at other convenient places with devices (pull wire) for stopping the conveyor in emergency. A pull wire at intervals of 8 m should be provided.
4. When two or more conveyors are operated together, the controlling device shall be so designed that no conveyor can feed on to a stopped conveyor. This may be interlocked.
5. Where conveyors extend to points not visible from the control station, they should be equipped with gongs, or signal lights to be used by the operators before starting the machinery so as to warn persons who might be in position of danger.
6. Conveyors shall be provided with automatic and continuous lubrication system or with lubricating facilities so arranged that oiling and greasing can be performed without the oilier coming into dangerous proximity of the moving parts. Scrappers should be provided to remove sticky material.
7. Workers should not ride on conveyors.
8. For repair/maintenance work, power must be totally stopped and danger-tag should be displayed. Belt cleaning by flammable solvent should be avoided.
9. Tension pulley - nips. and idler rollers should have fixed guard on their complete length of movement.
10. Moveable dead/counter weights should also be similarly guarded.
11. Static charge collectors should be provided close to the outrunning sections of the drive pulleys and idlers.
12. Elevated conveyors should have walkway with toe board (10 cm) and hand rail (I m) all along the length. Flooring should be non-slip type, particularly on sloping walkways. Handrail should also be provided on the belt side. Stop cord must be within easy reach.
13. Underpasses should have firm ceiling. Guards should be provided below all conveyors passing. over roads, walkways and work areas.
14. Conveyors running in tunnels, pits etc. should be provided with sufficient lighting, ventilation, drainage, guards, escape ways and maintenance clearance.
15. If a hopper is used at floor level to feed conveyor, the grill or guard should be provided to prevent falling of a person inside. Scrapper may be provided between the hopper bottom and the moving conveyor. This will restrict the excess flow of material and alert any person under passing it.
16. If two or more conveyors operate in series, it should be so interlocked that if one conveyor stops, all conveyors feeding it are also stopped.
17. In case of reversing or running away possibility, anti-runaway and backstop devices should be provided so that the load cannot slide or fall in the event of mechanical or electrical failure.
18. Overload stop devices like slip or fluid couplings and shear pins are desirable.
19. The loading and discharge points of powdered material on conveyor should have exhaust hood for dust removal.
20. If the material is combustible, the dust concentration should be below LEL, electric fittings should be flameproof, the conveyor should be grounded and its parts bonded to prevent differences in

electric potential. The container into or from which the material is conveyed should also be similarly grounded and its parts bonded.

21. Tight fitting clothing, safety shoes, goggles in dusty area and respirators are useful equipment.
22. Before starting maintenance or repair work, power should be locked in 'off position with key in pocket. It should be tagged also with 'not to start' notice.
23. Fixed scrappers or revolving brushes to remove sticky material from drum or pulley eliminate need of hand operation.
24. Static charge collector should be placed nearer to the outrunning sides of the drive pulleys and idlers.
25. Operators should be trained in safe work procedures near belt conveyors. They should be trained to avoid pinch points to save their hands and fingers.

Other types of conveyors are gravity conveyors either chute or roller type; screw conveyors (mostly used in cement, coal pulverising, pottery and grain plants), power roller conveyors, overhead chain conveyors (to transport material from place to place) bucket conveyors and aerial cableways.

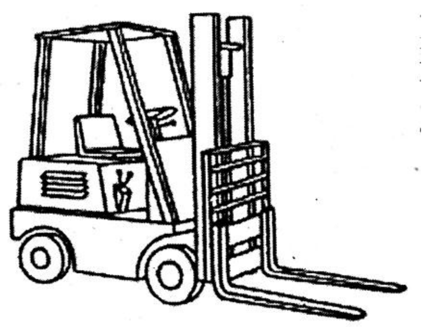
Screw conveyors should be covered at all times and the cover should not be opened without stopping the conveyor, or it should be interlocked. Buckets of conveyor should be enclosed throughout their length. Guard rails should be provided at picking point.

Pneumatic conveyor use air pressure or vacuum to push or pull the material in tube or ducting. Noise insulation is required at high noise points (mostly bends).

3.7 Industrial Trucks:

Power trucks usually operate by petrol, diesel, LPG i.e. by internal combustion engine or dry cell batteries and are extensively used in factories for handling of materials to and from stockpiles, to and from machines and through warehouse or loading platforms. They carry, lift, push, pull, stack and tier material. These trucks are of many types, such as fixed platform, elevating platform, forklift, motorised hand truck controlled by a walking operator, electronically controlled without operator i.e. Automated Guided Vehicle (AGV), straddle trucks, crane trucks etc.

The elevating type of platform is inserted under the skid elevated to lift it from the floor and the truck carries it to some other point. Each truck needs overhead guard to protect its driver.



The forklift truck makes the lift by means of a two prong fork instead of a platform and lifts the load up from the floor permitting high piling to conserve space. They could also be fitted with special attachments for handling barrels, paper reels, etc.

Safety precautions to be observed in operation of forklift trucks are:

1. The capacity of every lift truck should be marked on the truck and they should not be overloaded.
2. Loaded or empty forks should be carried as low as possible but high enough not to strike a ramp.
3. Care must be taken to avoid jerking when tilting a load forward or backward, specially when the load is at a height.
4. Personnel must not be allowed to ride on the forks.
5. Forks should be driven well under the load, preferably full length or at least 2/3 of the length.
6. When there is a danger of falling objects over the operator, canopy overhead guard should be provided.
7. Aisles, floor etc., should be maintained in good condition including proper lighting.

8. Mirrors at turning points (corners) to avoid front collision of two fork lifts coming in opposite direction.

Other operational safety precautions for all types of power trucks are :

1. Selection and training of the operator. He should be provided with DOS and Don'ts of the operation, specialties of the work situation and layout, plant rules, manufacturer's instructions etc.
2. While travelling, fork should be in lowered position and it should not be moved for tilling, lowering or lifting.
3. Lift trucks should be driven in the reverse direction when the load obstructs the vision or while coming down from ramps or slopes.
4. If any rail track is to be crossed, it should be done diagonally and not at right angles.
5. Before crossing a bridge, plate operator should make sure that it is properly secured.
6. Operators should be instructed –
   (1) not to carry persons on the truck.
   (2) to check the conditions of the vehicle before starting e.g. tyres, brakes and safety devices.
   (3) not to leave the truck on aisle space, and to park at the place allocated. Parking brakes should be applied. Power should be shut off.
   (4) not to turn a truck on a gradient.
   (5) not to carry out unauthorised repair or adjustments.
   (6) to notify defects known by them.

OSHA prescribes detailed safety rules for power truck operation.

Built-in-safety features are overhead guard on driver's seat with visibility, static and dynamic load test for overhead guard, overload warning devices, control levers, stability test, brakes test, forks load test for 3 times the rated load per fork, lifting chain load test for 5 times the rated load.

Load backrest extension, tiers guard, guards on chain, sprocket, gears etc., name plate with capacity, horns & flash light - are also required.

Other power trucks such as reach truck (carrying load under wheel base), side loaders (forklift trucks with side forks), picking trucks (to pick up material at different places from storage racks), pallet trucks (with forked platform mounted on small wheels to go under a pallet), platform trucks, tractor-trailer train, straddle trucks, straddle carriers and driverless electric trucks may be used as per requirement and should use specific safety precautions.

Inplant truck routes should be identified with markings e.g. width of aisleways, gangways, crossing for traffic, signs for narrow width of height etc. Blind corners and turns should be avoided.

Special precautions to drive trucks in flammable areas need necessary approval of a qualified person, area monitoring, mufflers on exhaust pipes etc.

Regular inspection and maintenance of power trucks should include checking of lights, brakes, battery, horn, lift system (fork chains, cables and limit switches), steering, controllers etc. and using wheel block and brakes while loading, unloading or any maintenance work.

Safety points for powered trucks should include three sections as under :

1. **Safe Operating Conditions :** The floor, storage and stacking areas, width of stacking aisle, lighting, loading and unloading areas, ramps and slopes, battery charging areas, pedestrians,

selection of proper size, type and capacity of truck, its maintenance and guards and view mirrors for the driver.

2. **Hazards in truck operations :**

(1) Overturning due to-
sudden braking, wheels striking obstruction, use of forward tilt with elevated load, driving down ramp with load preceding truck, striking overhead obstruction when reversing, turning on or crossing ramps, load shifting, wheels sinking into unsuitable floor or ground and overloading.
(2) Collisions.
(3) Floor level hazards - gullies, pot holes & debris.
(4) Overhead obstructions like pipes, cables and fixtures.
(5) Load unbalancing and falling.
(6) Truck failure due to brakes, steering, chains, hydraulic system, condition of forks, other attachments, horn, wheel nuts, tyres, electric wiring insulation, fuel supply systems on i/c engine trucks, cleanliness of power unit i.e. free from dust oil etc.
(7) Explosions and fire due to hydrogen while charging, contact of live cables with the' truck frame and shorting of battery terminals by metal tools or lifting tackle. Battery terminals should have suitable insulating covers.
(8) Carrying passengers without suitable seats.

3. Safe Operating Techniques and Training : All truck operators must be trained for safe driving and operating methods and matters stated in para I & 2 above.

See fig. 15.3 for different types of lift trucks.

3.8 Training of Operators :

See Rule 60(8) of Gujarat Factories Rules, 1963.

Proper selection and training of operators for any lifting equipment and power trucks are the most essential. The operators should be of more than 18 years of age, medically fit with regard to eyesight, hearing, reflexes and driving requirement and should have experience and attitude to operate the equipment safely. They should be fully trained to drive and operate the equipment with better judgement of distance, height, depth, clearance and turning. Knowledge of working of the equipment, routine checks and maintenance methods, signal code, colour code, hazards of materials and their handling should also be given.

Any safe equipment may be unsafe in untrained. hands. Therefore good training of all operators for mechanical handling is more important to prevent accidents due to material handling.

Each plant should devise rules for operators depending on types of industrial trucks provided, types of material handled, plant layout and type of environment.

Initial and refresher training should be given to truck operators. Such training programme should also consider types of truck accidents and losses already happened, operating habits of operators, properties of materials to be handled, faults and repairs with vehicles, filling of operator's daily reports, other performance forms and inspection and maintenance log. National Safety Council, USA has designed such forms. See reference No. I at the end.

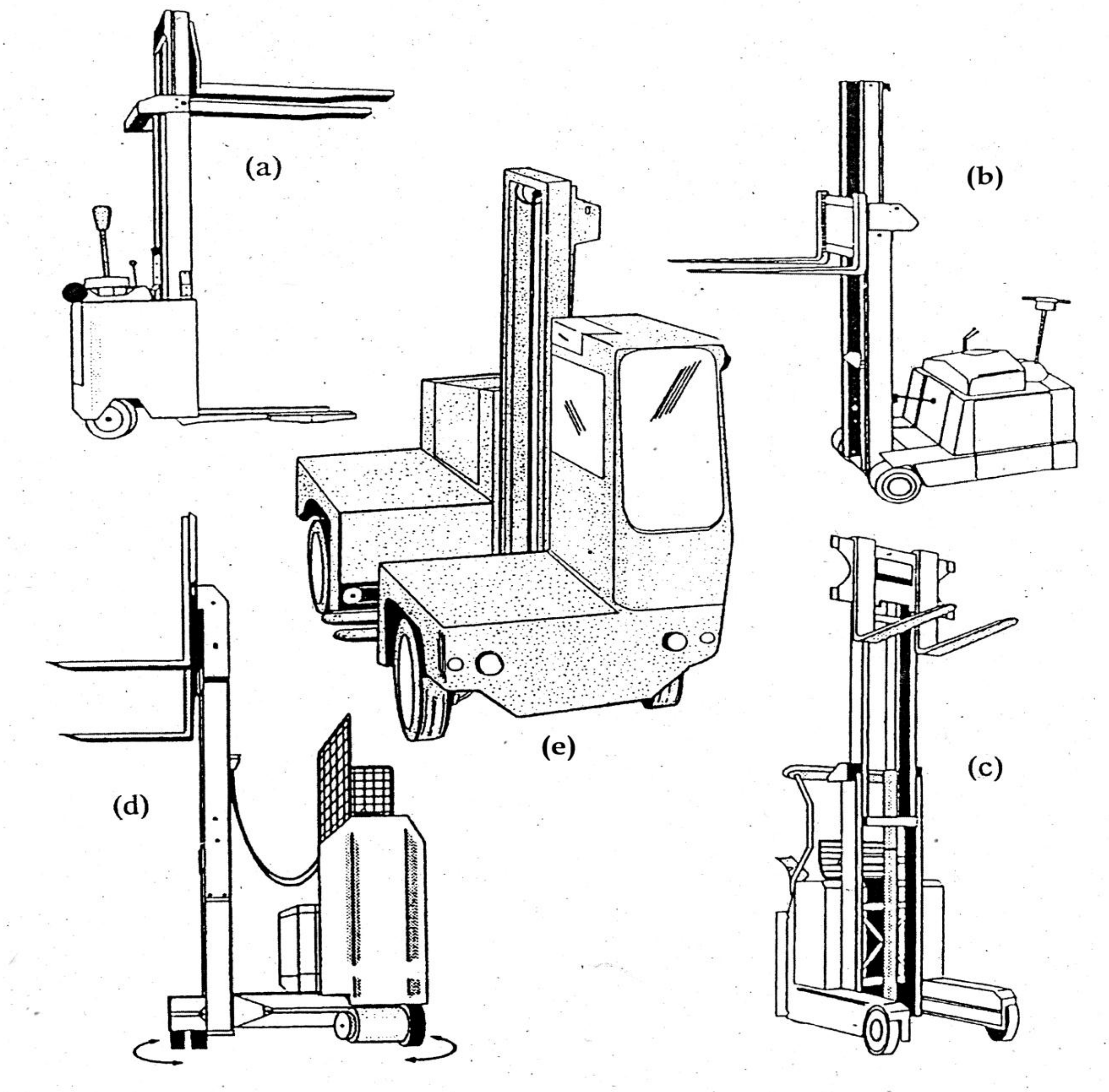


Fig. 15.3 Lift Trucks : (a) Pedestrian Pallet Stacker; (b) Pedestrian Counterbalanced Truck; (c) Reach Truck; (d) Four-directional Truck; (e) Side Lodading Truck.

Nine most common forklift truck accidents described by Theodore H Allegri in his book (mentioned as Reference No. 9 at the end) are as under:

1. Employee struck by forklift truck.
2. Forklift throws load on employee standing between the forklift truck and a fixed object.
3. Operator struck by falling parts while manually handling materials.
4. Operator or other employee is injured while boarding or stepping down from the forklift.
5. Operator fails to recognise serious hazard ahead and fails to slow down the truck.
6. Vehicle runs into other moving vehicles.
7. Vehicle backs or runs off the edge of the loading dock.
8. Part of operator's body protruding outside the running lines of the truck.
9. Parts fall on the operator.

Three main causes mentioned are :

1. Lack of knowledge or skill.

2. Operator being inattentive to the job.
3. Operator taking chances with full knowledge of the possible consequences.

Therefore an accident reduction programme should include

1. Provision of quality training.
2. Inclusion of follow-up into every programme.
3. Control of safe work practices.

3.9 Competent Persons, their Duties & Responsibilities :

Section 28(1) of the Factories Act requires that every hoist and lift shall be thoroughly examined by a competent person at least once in 6 months and a register in Form No. 9 (u/r 58 GFR) shall be maintained.

Section 29(1) of the same Act requires that lifting machines and tackles shall be thoroughly examined by a competent person at least once in a year or at an interval specified by the CIF. The record shall be kept in Form No. 10 (u/r 60 GFR).

For a competent person 7 years experience is required after B.E. (Mech. or Elect.) to test and certify hoists and lifts (Rule 2A GFR).

For lifting machines and tackles, B.E. (Metallurgy) is also allowed.

Duties expected by the competent person include load testing, heat treatment and checking of safe working conditions. Facilities for such work should be available at his workshop.

The thorough examination means visual examination, hammer test, detection of cracks, porosity and other damage and by dismantling the parts in order to arrive at a reliable conclusion as to the safety of the parts.

Duties of the Competent Person :

1. To study the provisions of the Factories Act, Rules and other statutes pertaining to hoists, lifts, lifting machines and tackles.
2. To study Indian Standards and other relevant Codes for design, operation, maintenance, testing and certification of material handling equipment.
3. To go on call to the manufacturers and users of the material handling equipment to test and certify them.
4. To keep ready the necessary load testing, heat treatment, NDT and other equipment to test the machine parts.
5. To keep ready the necessary statutory forms to be filled after the statutory examination or testing.
6. To report the defects to be rectified to the user/ customer and to the concerned authority.
7. To test and certify again after the rectification of the defects previously notified.
8. To get renewed the certificate of competency issued by the authority. .

Responsibilities of the Competent Person :

1. To calculate the SWL where it is not available.
2. To prepare a table of SWLs and load angles in case of a jib-crane or multiple sling - where SWL varies at different angles of the jib or legs and to display near the machine.

3. All hoists, lifts, lifting machines and tackles shall be thoroughly examined and tested and a certificate in the prescribed form (No. 9 for hoists and lifts and No. 10 for lifting machines and tackles) shall be signed specifying the SWL and defects found if any, and given to the user.
4. Different types of load tests including deflection test of an overhead travelling crane shall be carried out and certified.
5. Different types of defects shall be ascertained and remedial measures shall be suggested to remove them.
6. Defective parts (lengthened, altered or repaired by welding or otherwise) shall not be used again unless it is adequately tested, examined and certified in writing by him.
7. Annealing (low temperature heating and cooling) process shall be carried out under his supervision (1) at 6 months interval, of the parts made from a bar of 12.7 mm or smaller diameter or being used to handle molten metal or slag and (2) at 12 months interval, of all other parts in general use.
8. Any chain or lifting tackle subjected to normalising (instead of annealing) shall be thoroughly examined by him at, 12 months interval and particulars of such examination shall be entered in Form No. 10.
9. To attend an office of the authority or court, on call, in connection with any examination/test carried out by him or certificate given by him To obey the instructions given by the authority who issued him a certificate of competency, for the purpose of safety.
10. He should notify the serious defects and safety measures pointed out by him in relation to specific cases where a testing period needs to be decreased and intervention of the CIF is necessary as prescribed in Section 29 (l)(a)(iii of the Factories Act 1948 or where a serious concern from safety point of view is involved See also Part 6.8 of Chapter-6.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. The need of safety in material handling
2. Kinetics of Manual material handling.
3. Safe method of manual lifting of load. Draw sketch.
4. Health hazards of manual material handling.
5. Safety precautions for manual handling.
6. Safe work methods for lifting and carrying of different objects.
7. Safe methods of using accessories for manual handling.
8. Safe methods of storage of pipes, bars and long objects OR of Metal sheets and plates.
9. Handling precautions of hazardous materials.
10. Points of consideration in stacking and unstaking.
11. Floor and lay-out conditions for material handling.
12. The ergonomics of manual handling.
13. Safety provisions under the Bombay Lifts Act or the Gujarat Lifts and Escalators Act.
14. Different mechanical equipments and lheir uses for material handling.
15. Meaning and usefulness of Safe Working Load.
16. Meaning and usefulness of Proof Load.
17. Types of heat treatment and their uses in regard to lifting machines and tackles.
18. Points of care and maintenance of lifting machines and tackles.
19. General requirements of design, construction and operation of lifts and hoists.
20. Specific safety aspects of Lifts or Escalators
21. Types of lifting machines and their safety aspect.
22. Types of lifting tackles and their safety aspect.
23. Safety requirements in design, construction and operation of lifting machines and tackles.
24. Inspection check points for tackles.
25. Safety features of conveyors.

26. Safety precautions while using a fork lift.
27. Duties and responsibilities of Competent Persons with regard to lifting machinery.
28. Subjects for training to operators of lifting machines and tackles.
29. How much load is considered a safe load in manual lifting of load?
30. How will you safely handle or use following items?
    (1) Crow bar (2) Carton box (3) Bromine bottles (4) Acid carboy (5) Gas cylinder (6) Ladders (7) Fork lift (8) Jib crane (9) Hook (10) Oil drum (II) Bridge crane (12) Glass sheets (13) Piling of cotton bales (14) Multi chain sling (15) Gravity conveyor.

2. Write Short Notes on :

1. Hazards of manual material handling.
2. Hazards of mechanical handling.
3. Maximum limits of loads to be lifted as per GFR.
4. Body injuries due to manual handling.
5. Kinetic method of lifting a load.
6. Team work in lifting a load.
7. Safe use of rollers OR hooks.
8. Storage of barrels and drums.
9. Storage of paper reels OR Gas cylinders.
10. Methods of safe stacking
11. Classification of material handling process and equipment.
12. Transport equipment for material handling.
13. Derricks.
14. Chain Pulley block.
15. Safety devices for a lift.
16. Lifting gear.
17. Marking of SWL.
18. SWL of a mobile crane.
19. SWL for fibre ropes, wire ropes and slings.
20. Mobile Cranes.
21. Defects in wire ropes and chains.
22. Testing, inspection and maintenance of lifts and hoists.
23. Signalling.
24. Inspection and testing of heavy duty EOT crane.
25. Precautions while using slings.
26. Metallurgical defects in tackles.
27. Causes of chain failure.
28. Inspection of wire ropes.
29. Inspection of chains.
30. Defects to be checked in a crane.
31. Safe location of Lifting tackles.
32. Types of fork lift accidents and their preventive measures.
33. Thorough examination.
34. Built-in-safety features of a fork lift.
35. Hazards ,in industrial truck .operations.
36. Types of ropes OR Slings.
37. Types of conveyors. .
38. Norms for discarding wire ropes OR chains.
39. Different material used to make lifting ropes and their merits and demerits.
40. Operating practices for slings.

3. Explain the difference between :

1. Manual handling and Mechanical handling.
2. Individual lifting and team lifting.
3. Use of hand truck and use of hand trolley.
4. Use of hook and use of jack.
5. Hoist and Lift
6. Lifting machines and Tackles.
7. Sling and Ring.
8. Shackle and Swivel.
9. Jib crane and Gantry crane.
10. ETO crane and Mobile crane.
11. Monorail and Winch.
12. Belt conveyor and Screw conveyor.
13. SWL and Proof Load.
14. Defects in hook .and defects in fibre rope.
15. Duties and Responsibilities of a Competent person.
16. Passenger lift and Goods lift.

4. Comment on following explaining whether it is true or not?

1. Material handling does not add to the value of the product but adds to the cost of product.
2. It is not practicable to fix the same limit of maximum load for all persons.
3. Persons of same age cannot lift the same maximum load.
4. Statutory limits of maximum load are necessary.
5. Back pain is possible due to manual lifting.
6. If one person lifts 50 kg, four persons together can lift 200 kg load.
7. Workers should be trained for correct manual handling.
8. Chain requires quality marking while chain sling requires SWL marking.
9. Stress in leg of a sling increases as leg angle with horizontal increases.
10. Any safe equipment may be unsafe in untrained hands.

Reference and Recommended Reading

1. Accident Prevention Manual for Industrial Operations, NSC, Chicago, Illinois, USA.
2. The Course Material of the Central Labour Institute, Mumbai.
3. The ISI Handbook, 1984.
4. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
5. Modern Methods of Material Handling, Material Handling Institute, New York, Prentice-Hall.
6. The Stacking of Materials, Royal Society for the Prevention of Accidents, London.
7. A Safety Handbook for Mobile Cranes, Royal Society for the Prevention of Accidents, London
8. Safety Working Loads of Lifting Tackle, Linder London.
9. Material Handling - Principles and Practice Theodore H Allegri, CBS Publishers, Delhi 110032.
10. Fundamentals of Industrial Hygiene, NSC, USA
11. Accident Prevention Manual for Business and Industry by NSC, USA
12. Maximum Weights in Load Lifting and Carrying - ILO

CHAPTER – 16

Working at Different Levels

THEME

1. WORKING AT HEIGHT

Most of the fall accidents happen while working at height and most of them prove fatal. Therefore seriousness of fall accidents should be considered seriouslly.

1.1 Incidence and Seriousness of Fall Accidents

People are subjected to two types of falls, ethical fall and physical fall. Both are serious and need prompt prevention for the safe elevation of life. Accidents due to ethical falls spoil the self as well as the society and are much more in number than the physical falls which generally affect the person concerned only. This is just a comparison and we are, here, concerned with a narrow range of physical industrial falls only:

Incidences:

Table 5.7 in Chapter-5 states that there were 2.26% fatal accidents due to persons falling from height in India in 1995. Table 5.8 reports 82 fatal and 3950 non fatal industrial accidents due to persons falling in India in 1991. It also reports 33 fatal and 4706 non fatal industrial accidents due to falling bodies in India in the same year.

Table 5.20 gives fatal accidents in Gujarat. It points out that fatal accidents due to falling from height and struck by falling bodies were 25 and 11 respectively, out of 192 fatal accidents in 1995. This represents 13% and 5.7% respectively and the total of causes No. 10, II & 12 indicates 64 out of 192 i.e. 33.33% fatal accidents in 1995.

Table 5.22 gives total accidents of Gujarat in 1994. In its last row, total of causation No. 125 to 128 gives

2298 out of 15683 i.e. 14.65% accidents due to (1) Struck by falling bodies (2) Falling from height (3) Falling on the flat and (4) Falling into pits etc. These are the main types of fall accidents.

As reported in 'Accidents Facts, 1997' by NSC, USA, fatal fall accidents were 15% in-USA in 1996. It was 4% increase from 1995 and this fall death rate was 5.3 per I lac population.

Industrial fatal fall accidents were 573 out of 6210 (9.22%) 'in 1995 in USA. Deaths due to struck by objects were 546 nearly the same.

Non fatal occupational injuries due to falls in 1995 in USA are reported in percentage as under :

Type of Fall	Manufacturing	Private Industry	Construction
To same level	7.4	11.0	7.4
To lower level	3.1	5.1	11.9
Slips & Trips	2.4	2.9	2.6

All deaths (occupational plus non-occupational) due to falls in USA are reported asunder :

Type of Fall	1994	1993	1992
On of from stairs or steps	11563	1087	1197
On or from ladders or scaffolding	327	301	298
From or out of building or structure	477	509	513
Into holes or floor opening	93	107	99
Other fall from one level to another	1066	1156	984
Fall on same level from slipping, tripping or stumbling	600	520	477
Fall on same level from collision, pushing or shoving	4	9	6
Fracture, cause unspecified	3362	3353	3117
Other and unspecified fall	6358	6099	5955
Total	**13450**	**13141**	**12646**

Courtesy : Accidents Facts, 1997, NSC, USA

Figures of Fatal Industrial fall Accidents in UK are as under:

	1978		1979	
	No	%	No.	%
Falls of persons	30	16.2	28	15.6
Falls and movement of other objects.	18	9.7	17	9.5

Figures of National Safety Council, 1987, USA, as given by Willie Hammer, are 16.4% due to falls and 25% due to struck by or against objects.

All these data of India, UK and USA conclude that fall accideilts contribute @ 10 to 20% fatal and @ 12 to 30% nonfatal accidents.

1.2 Types, Causes and Control of Fall Accidents

Types of Falls:

Falls and accidents due to falling objects can be classified as under:

(A) Falls of Persons :

1. Falls from height viz. structure, floor, ladder, scaffold, platform.

2. Falls into depth (negative height) viz. wells, pit, sump, silos, ground opening, tank, vessel, excavation, ditches.
3. Falls on the same level viz. falling or slipping on the floor or flat at the standing level.

(B) Falling Objects (bodies):

1. Falls of objects from height viz. tools; machine part, equipment, material.
2. Falls of objects from the hands of the same person viz. tool, equipment, material being handled.
3. Structural collapse viz. wall, building, ceiling, pipe, ladder, scaffold, beam, truss.
4. Material collapse viz. falling of piles of goods, layers of begs, cloth, paper rolls, carton boxes, grain, cement and fertiliser.
5. Slides and cave-ins viz. earth, rock, sand, stones, snow, ice.

Most serious accidents due to falls and struck by falling bodies take place in mining and quarrying, building and construction, structural repair, alteration, cleaning, painting, demolition, maintenance and unsafe use of lifting and other equipment.

Major causes of such accidents are makeshift arrangement, unsafe floor, unsafe work practices, not using helmet, safety belt, safety shoes, unsafe use of vehicles, poor supervision, poor lighting etc.

Common Causes of Falls are :

1. Water, oil or grease not cleaned up.
2. Loose, defective or broken floor or toe board.
3. Scrap, chipping, swat and obstructions lying on the way.
4. Dusty, steamy or smoky atmosphere restricting vision.
5. Carrying too much load making it difficult to see over the load.
6. Warn out or unsuitable footwear.
7. Poor lighting, glare or shadows. .
8. Rushing instead of walking.
9. Defective or weak scaffolds.
10. Ladders, ramps, planks and platforms not rigid or safe for the job.
11. No or inadequate handrails.
12. Climbing oddly instead of using ladder.
13. Throwing instead of lowering tools or materials while working aloft.
14. Not using spectacles for clear vision.
15. Not using crawling board on fragile roof.
16. Not using a safety belt or using in a wrong way, e.g. not tying its free-end or tying it with a weak support.
17. Not closing the manhole cover or floor opening etc.
18. Allowing roof work and floor work at a time in the same vertical plane.
19. Touching of crane boom, hook etc. to weak or unfastened structure.
20. Non-compliance of statutory provisions.

Most of the falls from height prove fatal or result in serious fracture. Therefore their prevention or control is utmost necessary.

Control Measures for Fall Accidents :

1. Safe, sound and dry (non-slippery) surfaces for walking and working. Fencing, guarding and toe boards.
2. Safe helmet, safety belt, foot-wear, etc.
3. Safe practice in walking and working. No excessive load lifting.
4. Safe means of access while working at height or depth.
5. Use of crawling board, cat ladder, fall arrester net etc. while working on fragile roof.
6. Use of Safety work permit for working at height or depth.
7. Safe and sound stairs, ladders, scaffold etc. and safe use thereof.
8. Good lighting and supervision, cutting off power supply in overhead electric lines.
9. Safety cordon to disallow persons in the area where any object may fall from height.
10. Removal of 20 causes mentioned above. Other details are given below.

See Rule 41 for overhead protection and Rule 42 for slipping, tripping, cutting, drowning and falling hazards, of Building and other Construction Workers Central Rules, 1998. See their summary in Part 7 of Chapter-28.

Fall Energy:

Energy requires for skull fracture is 30 to 75 fool pound. White and Brown indicated that 18 mph (27 ft sec) is a velocity (of fall or impact) which may kill 50" of all persons against a hard surface. This is equivalent to a free fall of 11 ft. Willie Hammer has given following figures:

Effect on man	Impact Velocity		Equivalent Height of fall
Fracture of	**fps**	**mph**	**inch**
Skull	13.5-22.9	9.5-15.0	37-91
Feet & Ankles	12-13	8-9	25-30
Lumber & Spine	8	6	12

Ability of a human body to sustain effect of fall depends on (1) velocity of an initial impact (2) magnitude of the deceleration and (3) orientation of the body on impact.

The kinetic energy of a body falling on a hard surface can be given by a formula :

$$E = \frac{Wv^2}{2g}$$

where w is the weight in pounds, v is ft/sec, g is gravity constant i.e. 32.2 ft/sec/sec, and E in ft-pound. If E and w are known, falling (fatal) speed (velocity) can be known by the same formula. Deceleration 'd' is given by $d = v^2/2h$ where h is the falling, height or stopping distance.

1.3 Statutory Provisions

Section 32 and 33 of the Factories Act, 1948 provide precautions regarding floors, stairs, means of access, pits, sumps, openings in floor etc. Accordingly all floors, steps, stairs, passages and gangways should be of sound construction, properly maintained and kept free from obstructions and substances likely to cause persons to slip. Steps, stairs, passages, gangways with substantial handrails, fencing and safe means of access to every work place, shall be provided to prevent a fall and ensure safety.

Every fixed vessel, sump, tank, pit or opening in the ground or in the floor whose depth, situation, construction or contents are dangerous should be securely covered or fenced.

Section 36 prescribes details of entering any confined space. Before such entry, the space is to be made free of dangerous fume, gas, vapour or dust. Work permit system should be followed and a suitable breathing apparatus and safety belt to be used by the person.

Section 36A requires a portable electric light up to 24 V and a flameproof lamp for flammable atmosphere.

Dimension of manholes, under rule 64 of the Gujarat Factories Rules are given as circular 41 cm dia or rectangular 41 cm x 31 cm. Rule 68 of Maharashtra Factories Rules gives these, dimensions as : circular shoulder width of the person concerned plus 8 cm in diameter, or rectangular - shoulder width plus 8 cm length and 30 cm width.

Rule 68 describes the ladder quality that it should have hooks or an effective non-skid device.

Rule 68E, GFR, provides for suitable and sufficient ladders, duck ladders or crawling boards and a permit to work system while working on fragile roofs at a height exceeding 3 mt.

Clause 2(0) of Sch-19 on Chemical Works u/r 102, GFR, defines 'confined spacer See Part-2.1 for definition.

Rule 61A of the Tamil Nadu Factories Rules 1950 prescribed safety belt details. It should be of leather straps of more than 5 cm width and a D ring at the back for fastening a rope. The other end of this rope shall be securely tied or hooked to some suitable rigid fixture. A competent person shall examine this belt every six months and certify its suitability. Its register shall be produced before the Inspector on demand.

Schedule 19 and other Schedules u/r 102 of the Gujarat Factories Rules prescribe rules, for working at height and depth.

Chapters VIH, XIV, XV, XVI, XVII and XIX of the Building and Construction Workers Central Rules, 1998 should also be referred for safety provisions to work at height and depth.

See Part 7 of Chapter 28.

1.4 Indian Standards

Some IS are :

Ladders - safety code 3696, dog-step steel 8450, for inland vessel 4647, for ship's use 6176, vertical steel 8172, wooden 1634, 4435, turn table for fire fighting 932, extension for fire fighting 930, hook for fire fighting 929, aluminium for fire brigade 4571, pilot 4383, orchard 8942.

Hazards at workplaces - falling material, fall prevention etc. 13416 (Part I to 5).

Scaffolds - safety code 3696, steel 2750, steel tubular 4014.

Platform - for industrial trucks' 12157, folding and base containers 7341, freight container 6927, 6928, 13288, stability test 7631.

Gangways, aluminium shore- 10558, Gantry cranes, design 3177, for lifting air cargo 12462.

Safety nets (fall arrester) 11057. High Chair, safety requirements 6185, push chair safety requirements 6618, wooden tests 5416, chairs and tables, classroom 4837.

Belt - aircraft safety, lap 10682, belt (safety) and harness 3521. Body protection equipment, selection 8519. Footwear for steel plant 10348, Breathing apparatus 10245, Respirators 8522, 8523, 6194, 8347, life jacket 6685.

Structural - loading standards 875, movement, field monitoring 12023, chain 5616, steel work erection, safely code 7205.

See also Part 3 of Chapter-25 and Part 2.2 of Chapter-15.

1.5 Safety requirement while Working at Height

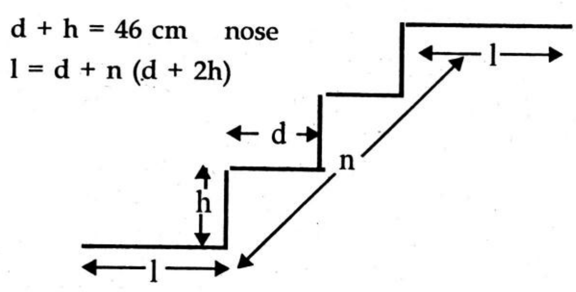
Falls happen due to falling from stairways, runs, ramps, gangways, floors and ladders. Therefore safety aspects of their design, construction and use are explained below:

1.5.1 Stairways:

The slope of a stairway should be 30° to 35° with the horizontal. The tread width should not be less than 24 cm plus a non-slip nosing of 2.5 cm. The riser height should not be more than 20 cm and not less than 12.75 cm and should be constant for each flight. All stairways should be fitted with railings on the open sides and hand rails on sides which are otherwise enclosed. The height of the railings at the stairs should be not less than 75 cm or more than 90 cm measured from the top surface of the stair tread. The stair landings should be protected by railings and toe-boards. Non-skid strips on stair treads can prevent slipping.

Adequate lighting on stairway should be provided to avoid accidents.

Two formulae are quoted in ILO literature.



where d is the depth of the step, h is the height of the riser, n the number of steps and 'I' the length of the landing.

Recommendation for h is 16 to 20 cm, then 'd' should be 30 to 26 cm.

The width of the staircase should be more than 75 cm. Instead of continuous steps, groups of 5 to 6 steps should be preferred. Turning staircases should be avoided. Steps in outdoor staircases should have a slight (1 to 2%) slope towards the nose to run away the water.

Stairways should be of fireproof material to give support for a longer time. Stairwell acts as a chimney. Therefore it should be kept free from smoke and gases. This can be achieved by providing top and bottom ventilation and self-closing fire doors on each landing. Double doors are provided to form an air lock. In high rise building, positive ventilation pressure is applied in case of fire, to drive away smokes.

Proper signs and symbols should be marked in traffic aisles. Arrows for escape routes are necessary.

1.5.2 Ramps, Runways and Gangways :

The slope of ramps, runways, gangways etc. should be as small as possible and the recommended maximum is 15° to the horizontal. Cleats not more than 40 cm apart, should be provided on ramps With steep slopes. Toe-boards should be provided where a ramp extends over a work place or a passage. Wire screens are necessary on the sides, if there is a risk of materials falling through the sides.

Runways are long with uniform slope as they are at arodram.

Chapter- VIII (R.82 to 85) of the Building Workers Central Rules, 1998 are pertaining to runways and ramps.

1.5.3 Floors and Platforms :

The design should consider all types of load in the form of materials, persons and other forces acting on the floor. Acid proof bricks laid in acid resistant plaster should be the choice of flooring for a workroom in which acids are handled. Unprotected floor edges situated at heights and openings, sumps, pits etc., in platforms or floors should be protected by railings, toe-boards or guards. The height of the railings from the base should be not less than 90 cm or more than 120 cm. It should have intermediate members to shorten the gap less than 47 cm. The toe-board should not be less than 15 cm in height.

Floors should be of sufficient strength and shall never be overloaded. They should be non-slippery, free from holes, openings, pinch points, uneven surfaces, irregularities, accumulation of oil, water, waste, dust etc. Near wet processes and water showers, proper drainage should be provided.

Open gutters, kerbs and floor openings (holes, chutes, inspection plates) must be fenced or guarded to protect unwary persons or prevent material falling through it to the floor below.

Non-conductive floor in explosive atmosphere pose special hazard. Discharge of static electricity generates spark which can ignite the explosive mixture near the floor. Therefore steel tipped or nailed boots or dropping of steel tools on such floor is hazardous. Such floors must be earthed properly.

In industry, criteria for floor selection are many. In addition to strength, comfort and cost, resistance to (a) wear and abrasion (b) chemicals (c) fire (d) environmental factors and (e) material in process are also to be considered.

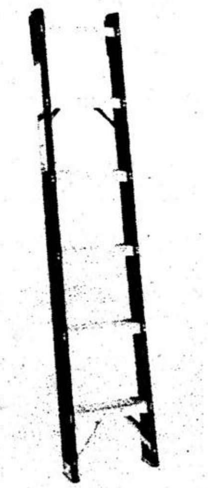
Floors are also of many types. Acids and alkali should be avoided on concrete, granolithic, linoleum, magnesite, quarry tile, ceramic, wood and terazzo type floor. Solvents and oils should be avoided on rubber, thermoplastic, vinyl and vinyl asbestos floor. The cleaning process should not damage the floor affecting its strength or anti-slip properties. Cleaners like soaps, natural detergents, alkaline solution, abrasive powder and damp floor cloths should be used.

Slope is an important factor in floor design. 1 to 2% gradient towards drain helps ensure to flow away water and keep the surface dry.

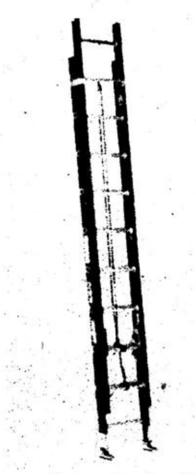
1.5.4 Ladders:

Ladders may be classified under two broad categories, the portable and the fixed. Since the portable ladder is a rather hazardous piece of equipment, every effort should be made, wherever possible, to replace it by fixed stairs, fixed ladder, scaffolding or any other suitable arrangement. Not using ladders where required is a common cause of serious accidents. Men climb on machines, equipment, boxes, barrels, etc., to get access to places above the floor and thus get involved in accidents.

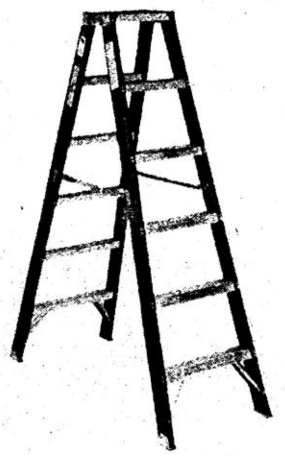
Step Ladder



Shelf Ladder



Extension Ladder



Step Ladder
Entry from either side

Ladders should rest on firm ground and its top should extend at least 1 in above the place of landing.

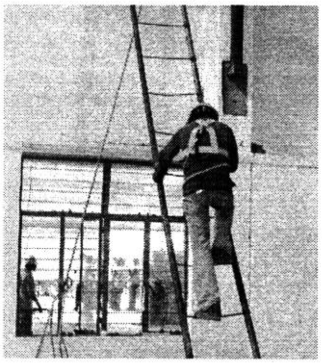
Step (Swing back) ladders and folding trestle ladders : In situations where there is no suitable facility to lean the ladders, such ladder should be the right choice. Step (Swing back) ladders are generally provided with a convenient platform and a hand rail at the top.

Fixed ladders : Wherever the length of a fixed ladder exceeds 9 m, it is necessary to provide a crinoline for ensuring the safety of the user. Alternatively, a. suitable fall arrester should be used. In the fall arrester a slide runs smoothly up and down a steel cable fitted along with the centre of the ladder. The slide is attached to the user's belt by a chain. The slide moves up and down the cable as long as the user climbs or descends at the normal speed. If the user falls, the abrupt pull on the slide causes it to catch on the cable and thus the fall is arrested (controlled).

Transport of ladders : Ladders should be carried always with the leading end at least 2 m above the ground. Long and heavy ladders should be carried by two or more persons. The ladder is safest and easiest to climb when it is at an angle of about 75° to the horizontal, i.e. to a slope of about four vertical to one horizontal.

Portable ladder should not be more than 20 ft long.

Non-slip devices for ladder feet : Slipping of the feet of the ladder can be prevented by fixing non-slip ladder shoes to the stiles. They are of fixed or pivoted type, and the soles may be of rubber, cork, braided rope, leather, felt or lead. Steel spikes or pointed ferrules fixed to the feet of the stile, also serve as ladder shoes. Lashing the ladder by side guys should be resorted to where no anchorage is available near the top. A very long ladder should also be tied by guy ropes as shown in the figure.



Climbing ladders : A person ascending or descending a ladder should always face the ladder. Facing away from the ladder while descending is a dangerous practice. When climbing or descending a ladder, the rungs should be held firmly hand over hand. It is easier and hence safer for a person to cling on to a rung than to a stile, in case the foot slips. However, in the case of fixed ladders with wide Steps and narrow stiles, it is safer to hold the stiles.

Ladder behind door is unsafe condition

Tools should be carried in a holster attached to a belt or in a tool bag or box slung from a strap over the shoulder. The safest procedure is to hoist or lower the tools and materials by a rope. There is greater danger of slipping when the footwear or rungs are wet, dirty or covered with paint, plaster, grease or oil. Therefore they should be cleaned.

Work on ladders : Working from the top of a single ladder can be particularly dangerous when the job requires the use of both hands. The safer way is to stand on a rung about a meter below the top rung to which safety belt is attached. The equilibrium of ladder can be easily upset if one leans sideways.

Misuse of ladder : Use of trestle ladders as single ladders can easily lead to accidents. **Crawling ladders** used over roofs are not designed for use as ordinary single ladders. They should be supported throughout their length. Likewise, single ladders are not designed to be used in a horizontal position as bridges or platforms. A door should be closed before placing ladder over it. Do not use metal ladder near live electric lines. Use the ladder by facing toward it and not otherwise. Ladders should not be put on aisle. Do not rest it on drums, machines, boxes etc. to reach at height. Filling in cracks and .faults or covering up repaired portions with putty and paint is a dangerous practice as the potential weak points are then hidden and cannot be detected during inspections. Ladders should not be allowed to lie in the open exposed to the sun and the weather.

Chapter-XV (R. 172 to 174) of the Building Workers Central Rules, 1998 gives some provisions for ladders.

1.5.5 Scaffolding:

(1) General Requirements:

A scaffold is a temporary structure that provides support for workers, plant and materials used in building, construction, maintenance, repair and demolition work.

The scaffold serves two purposes. One is to provide a convenient platform for persons to work at height and the other is to provide a safe means of access to all places where any person may be required to work at any time. Accidents at scaffolds are generally caused either due to direct collapse of the scaffold or as a result of persons or material falling off the scaffold.

The scaffolds should be of sound material, sufficient strength (4 times the expected load) and properly designed. Their erection, alteration and dismantling should be done under the supervision of a competent person. They should be securely supported or suspended and should be properly strutted or braced to ensure stability. Normal size is 4 cm thick x 23 cm wide x 3-4 m long.

Steel components of tubular (normally 5 cm dia) scaffolds should conform to IS:2750 and 4014 for Steel Scaffoldings. Wood and bamboo should meet the specifications laid down by the Forest Research Institute and College, Dehra Dun.

Overhead protection, not more than 3 m above the work platform of the scaffold becomes necessary if overhead work is going on. Similarly for the persons working or passing under a scaffold, at least 30 cm projected canopy or screen should be provided at the scaffold working level.

In high wind or storm work on scaffold should be avoided. No hot work should be carried out on wooden platform. Fire fighting facility should be kept nearby.

Means of Access : Failure to provide such access has caused serious accidents. The safe means of access may be ladders, portable or fixed, ramps, runways, gangways or stairways. It is recommended that portable ladders should not be used as a means of access where the height of the scaffold platforms exceeds 3.75 m. Slope of the ladder should be 4 vertical to I horizontal. It should rise I m above landing platform and securely fixed at upper end. The use of cross braces or framework of the scaffold as a means of access should not be permitted.

Width of working platforms : The following minimum widths are recommended as a general rule.

1	If the platform is used as a footing only	0.7 m
2	If the platform is used for the deposit of material	0.9 m
3	If the platform is used for support of any higher platform	1.1 m
4	If the platform is one upon which stone or bricks are dressed or roughly shaped	1.3m
5	If the platform is used for support of any higher platform and is one upon which stone or bricks are dressed or roughly shaped	1.5m

Railings and toe-boards : A common cause of accidents at scaffolds is the failure to provide railings at the exposed sides of the scaffold platforms. Often, the failure is when the scaffolding is erected for jobs of short duration. Where materials are stacked on a platform, the height of the toe-board may have to be raised; or it may even be necessary to cover the entire space between the top rail and the toe-board with wire netting or planks. Normal height of railing is I m and toe board 15 cm. '

Boards and planks in working platforms, gangways and ramps : For platforms of wooden planks, in general, the spacing should not exceed the following:

Planks 32 mm thick	1.0m
Planks 38 mm thick	1.5m
Planks 50 mm thick	2.6m

Boards or planks which form part of a working platform, gangway or ramp should not project beyond their end supports to a distance exceeding four times the thickness of the board or plank. 50 mm projection is desirable. Overlapping of boards is unsafe.

Hazards and Safety measures: Scaffolds should never be loaded in excess of the working load for which they are designed. Wood scaffolds are not generally painted. However, in case of ladders and certain permanent types of scaffolds such as the mobile scaffold, protection is generally provided by periodically treating them with a coating of linseed oil.

Main hazards with scaffolding are:

1. Unsuitable or faulty material of construction.
2. Inadequately supported scaffold boards.
3. Improper platform width and thickness.
4. Non-securing or bracing scaffold to the structure. Damaged or wrong couplers.
5. Unsecured ladders slipping.
6. Omission of guard rails or toeboards.
7. Overloading the scaffold.
8. Erected on uneven ground.

Scaffold foundation should be verified before erection. Loose or friable packing like bricks should not be used as support. For height more than 15 mt, steel scaffold should be preferred and not a wooden one.

Inspection' after 7 days and after every damage is necessary. Points to be checked include : stability, ties and fixing, alignment of members, bending, tightness of lashing (3r couplers, planks, platforms, guard rails, toe boards and condition of ladders.

Warning notice should be displayed near incomplete or damaged scaffold.

Dismantling should be carried out in the reversed order to erection. Materials should not be thrown from heights and should not be left lying here and there. They should be properly collected.

After completion of work, all scaffold materials should be stored in a dry protected place using racks, boxes or trays. The damaged parts should be replaced or repaired, cleaned, treated with preservative or paint. Couplers and other fittings should be lubricated.

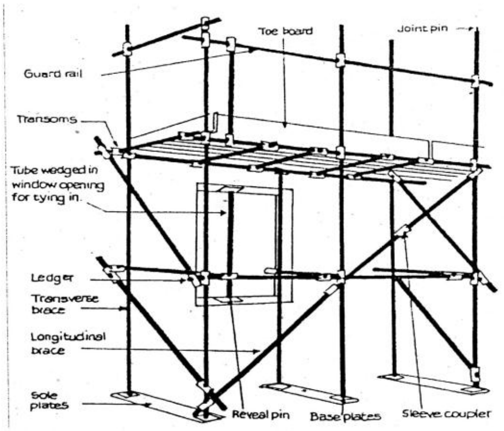
Chapter-XIX (R.188 to 205) of the Building and Construction Workers Central Rules, 1998 gives provisions regarding scaffold.

(2) Types of Scaffold :

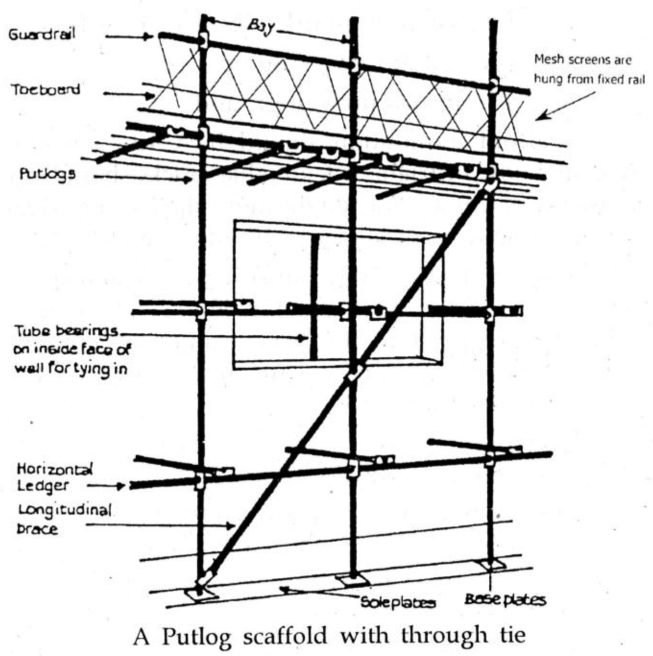
Some common types of scaffold are as follows :

1 Pole type scaffolds :

It may be an independent structure or the putlog type erected and supported near wall or another structure.



Independent tied scaffold with a reveal tie



A Putlog scaffold with through tie

The uprights (vertical poles) should rest on strong foundation to support load without settlement. They should not be kept more than 3 mt apart. Tubular uprights have steel base plates placed on wooden sole plates. Soft ground should be well rammed and levelled.

Fixings like steel bolts, nails or fibre rope of approved size, joint pins and couplers should be properly fitted. For load bearing right-angled or swivel couplers should be used. Putlog couplers are useful for putlog members only. Putlog members (horizontal) should at least 10 cm be inserted in wall. Bracing (diagonal connection) should be tied to ensure structural stability and prevent buckling. To prevent overturning the scaffold should be secured at intervals not greater than 7.6 m vertically and horizontally.

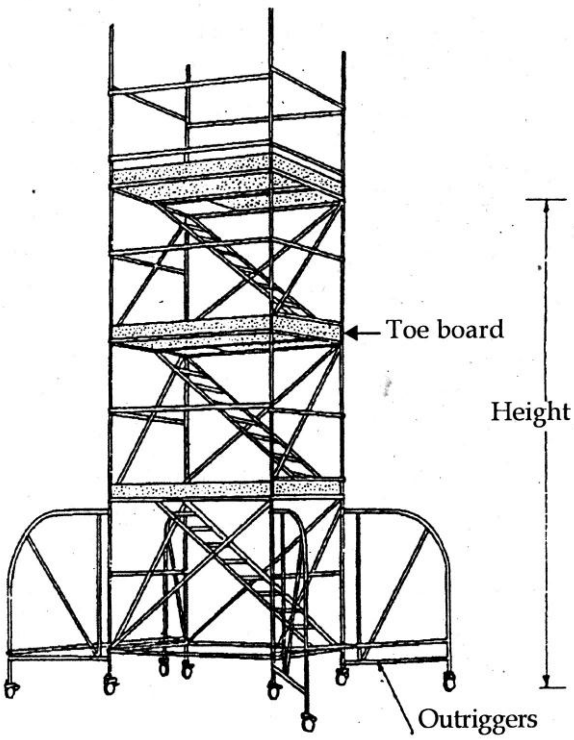
2 Rolling Scaffolds or Mobile Towers :

Such scaffolds move on rollers (wheels) or castors with wheel locking device. They are portable and most useful for maintenance work.

To prevent overturning, height should not be more than three times the minimum width of the base. Minimum base length should be 4 ft. While pushing or pulling the tower, persons should not ride on it. Tools and materials should be removed before moving.

The top working platform must have handrails and toe boards. It should support 30 lb/ft distributed load. Rigidity of the tower is secured by diagonal bracing on all four sides and on plan.

Moving the tower by pulling at the top or leaning sideways should be avoided.



Rolling or mobile tower scaffold

Rolling or mobile tower scaffold is shown below.

3 Outriggers

Rolling or mobile tower scaffold Outrigger Scaffolds:

It is a balcony type cantilever scaffold resting on wall. If other types of scaffold are possible, this type should not be used.

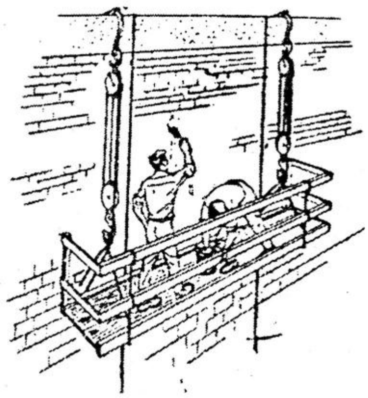
The outriggers should be passed right trough the wall and be secured on the inner side. Supporting hook between brick joints is dangerous.

Platform should not project beyond 2 mt from the wall. Guard rail and toe board should be provided.

4 Swinging (Hanging) Scaffolds :

Here the platform is hanging by two chain pulley blokes, ropes and hooks on supporting beam. Suspended platform can be raised or lowered as per need. Movement of both the ends should be simultaneously. The anchorage and the suspension gear should be strong enough to withstand the load with good factor of safety. Suspension ropes should withstand 6 times the intended load. Rope diameter shall be more than 0.75 inch.

A safely rope shall be provided in addition to .the suspension ropes.


Hanging scaffold

The width of the platform should be more than 50 cm and less than 90 cm. Guard rails and toe boards necessary, on all the three sides open. The platform should be lashed or secured while in use, to prevent swaying.

Each person working on swinging scaffold should wear safety belt with lifeline attached to an anchorage other than the scaffold itself.

5 Suspended Scaffolds:

Two or more platforms are suspended by ropes from overhead outriggers anchored to the building.

Such scaffolds are designed with a factor of safety 4 and shall never be overloaded. Anchor plates should be tied with U bolts. Counter weights are used to prevent overturning. Wire ropes (FS 6) are used to support scaffold. Hoisting drum (like winch) is used with at least 2 dead turns. Gap between handrail and toe board should be covered by a wire mesh of 38 mm and 16 gauge wire. Overhead protection should be provided if risk of falling objects is possible.

6 Boatswain's Chair:

Boatswain's chair is used for supporting and hoisting single person in sitting position. General chair (seat) size is 60 cm x 30 cm, with 25 mm thick timber. Cleats extending in front to at least 23 cm should be securely fixed under the chair at both ends. The chair is supported by a suitable sling passing through the four corner holes in the chair for proper stability. The suspension rope is fixed to an overhead support or passed through a pulley block fastened to such support. The free end is secured to a conveniently accessible anchorage and the person in chair must wear a safety belt, the life line of which is secured to the tackle supporting the chair. Fibre rope slings should not be used if the person in the chair has to do welding or cutting work.

1.5.6 Safety Belts and Harness :

In addition to all engineering controls and work permits, personal protective equipment should not be forgotten while working at height or depth.

Safety belts of various types are available. Pole safety belt, general purpose safety belt with or without remote anchorage and harness (man hoisting by another man) type safety belt are in common use. They should fulfil IS specifications stated in foregoing Part 1.3. They are available in leather and webbing of natural and man made fibres, of which, webbing is superior to leather. Webbing can withstand loads 3 to 4 times that of leather of the same size. Web material maybe cotton, nylon or dacron. While selecting a belt, its normal and emergency use should be considered. Life Lines of manila rope of 19 mm diameter or nylon rope of 13 mm diameter are suitable provided a shock absorbing device is available. Care of belts is always necessary.

Respiratory equipment should be selected depending upon the working environment.

Harness consists of a safety belt and rope or lifeline. It can stop a person falling or he can be pulled out if working below in a confined space.

(1) General Requirements:

All workers working at height of more than 2 m (window cleaners, construction workers etc.) must wear safety harnesses i.e. safety belts connected with ropes. The belt should be tied with the body while the free end of the rope should be anchored with a fixed unbreakable sound structure or should be held by another person standing outside a confined space when the wearer is working inside. The belt and rope should be of sound material, examined by a competent person every six month and maintained in very good condition.

Length of the rope is normally 2 ill since more fall height and sudden arrest may cause internal injuries to the workers.

But in case of working in depth the rope length should be more than 2 m and extending up to the bottom level of working since the worker is to be pulled out when he gives indication of any difficulty to him or when it is observed by the person holding the rope, standing outside and watching the person working inside.

Workers should be trained, encouraged and supervised to wear safety belt properly because it can save their precious lives.

All safety equipment are to be freely supplied by the employer and it should be seen that workers use them. This is a statutory requirement.

Safety belts are required for workers working on towers, masts, windows and building projects and also in confined spaces like tanks, boilers, gutters etc. Car and aeroplane occupants also need safety belts to be protected from crashing and overturning.

Free end of the rope shall never be anchored on a structural member being placed or any loose or weakened structure. Supervisor and the worker must ensure this. Wrapping of free end (rope) on waist is a wrong practice. Increasing length of the rope without permission can also lead to hazard. Anchorage point should be at such height so that there shall be minimum slackness in the line. It shall never be lower than the belt attachment to the restraining line.

Safety block (like chain pulley block or hoisting drum block) is used to connect the wire rope with the safety belt to allow more freedom of movement. A sudden pull operates lock or brake to stop the rope. Because of a friction brake on the rope drum, jolt is avoided and the falling person is stopped smoothly. In another design, a centrifugal brake is applied on the drum so that the person descends slowly to reach the ground.

Tensile tests and drop tests are carried out on safety belts and apparatus used with them.

Safety belts should be kept in a cool, dry and well ventilated place. Regular cleaning, visual inspection for defects and repair only by a competent person are necessary for good maintenance.

See Part 5.6 of Chapter-25 for further details of fall protection.

See Chapter-XVI (R.175 to 180) of Building and other Construction Workers (Central) Rules, 1998 for catch platforms, safety belts, nets etc.

(2) Types of Safely Belts:

Mainly four types of safety belts are .in practice:

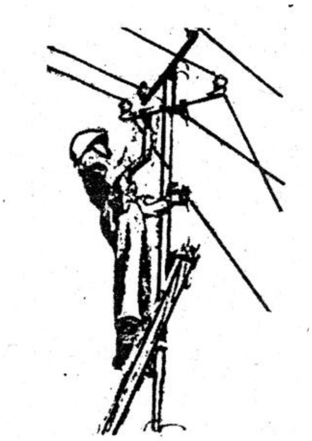
1 General purpose Safety Belt :

A Full Safety harness with fall arrest block

It consists of a waist belt, a restraining line (lifeline) and the metal components. Straps covering shoulders, chest, waist and hips are preferable as by wearing it the forces during fall will be absorbed not only by the trunk but also by the legs. Choice of model depends on working method, time of work, environmental factors etc. Rope (normally 2 m) is attached to D ring secured to the waist belt.

For window cleaning, straps are long enough to fit windows and terminate in snap hooks for anchor on each side of the window. Two restraining lines are used for window cleaner's belt.

2 Lineman's or Pole Safety Belt :



To climb on poles, towers, masts, trees etc. these belts are used. They are used as support while climbing and protection while falling. Here waist belt is fitted with 2 D-rings at different points. The length of the restraining line is adjustable by a buckle. Generally fall is restricted to 60 cm

3 Harness (Man hoisting) Safety Belt :

It is used for working in a confined space, silo, tank, vessel etc. The life line is held by a person standing outside to rescue the wearer when he is unable to come out by his own efforts. On the rescue line there is a wrist strap by which the wearer can be hauled up through a manhole or other opening.

Work permit should be followed and the workplace should be made free from any toxic/flammable vapour and oxygen deficiency. See Part 1.8 of Chapter-19 for more details.

1.5.7 Fall Arrestor or Anti fall Device :

Fall arrest or antifall device

Here waist belt is connected to a sliding anti fall device which automatically stops while moving in fall direction. Here fall arrest distance is small due to close (short) life line.

Anti fall systems are of two types (1) With a sliding and blocking device on a vertical safety support (pole, cable rail) (2) With an automatic catching device for rolling, unrolling and blocking a tether (cable, rope, strap). Specific braking system includes an absorber of kinetic energy used with a tether (for details see Reference No. 5 at the end of this Chapter).

A competent person should be consulted for selection of appropriate device. A cross belt is tied with the body and a sliding mechanism moves with the bjody in upward direction but it will be

locked and stop the fall at the descending movement. Other type allows the horizontal (to and fro) movement but will catch the falling body through rope and a shock absorber.

1.5.8 Safety Nets .

Where safety belt is not possible or in addition to safety belt for further safety of a person, particularly when fall height is very high or falling in sea or deep water is possible, or work surface is fragile and sudden fall is possible, safety net is very much essential to catch a falling person. Net is useful to stop a fall of a person as well as of falling objects. For stopping falling material, the mesh size should be small.

The net and the structure to which it is attached should be capable of catching and supporting at least two persons at a time.

The nets are made of synthetic fibres which are strong, light weight and weatherproof. Diameter of the mesh cords and that of the border cord should be at least 3 mm and 8 mm respectively.

Standard net size is 6 x 4 m but it can be manufactured of required sizes also. The mesh size of 5 x 5 cm is preferable. For falling objects that size should be 3x3 cm.

Four corners should have eyes to support. Big net should have eyes every 2 m on the boarder cords. Two nets can be connected with each other to cover more surfaces.

While attaching net with the structure, some safety distance should be maintained. It should not be lower than 3.5 m below the working level and less than 3.5 m above any object or structure below the net. The net must project at least 2 mt outside the falling area.

Nets should be cleaned regularly and checked periodically for cuts and other objects. It should have serial number so as to keep record of maintenance.

Nets should be kept on pallets in a dry, cool and well ventilated place. It should be kept away from chemicals and hot materials.

1.5.9 Working on Roofs :

Serious accidents happen due to fall of persons working on roofs. Fall through fragile roof sheeting, loss of balance due to the slope of the roof or effect of wind and insufficient care while working at the edge of the roof constitute the principal causes of such accidents which could be prevented by appropriate safety measures like crawling or walk-boards, railing, safety belt and safety net.

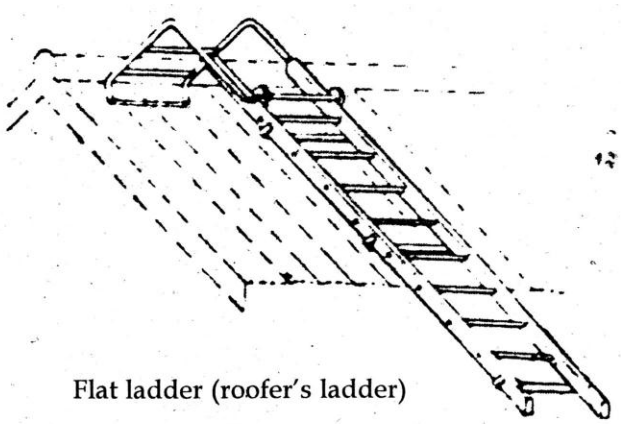
Use of a safety belt alone' while working on a fragile roof or at a height more than 6 ft (2m) is not permitted. It is dangerous and many fatal accidents have happened because of this condition. Sound platform, adequate support or safety net should also be provided.

See Part 5.6· of Chapter-25 for more details of fall protection.

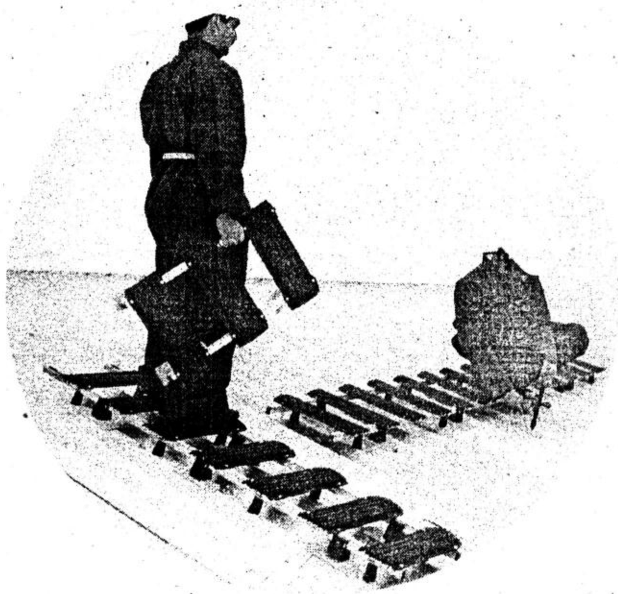
Factors affecting fall of roofers are working height, nature, shape and slope of the roof, roof covering material, roof condition and the weather.

Low-strength roofing materials are asbestos, cement, glass, plastic, wood and roofing tiles. Heat, rain, humidity, pollution and corrosion spoil the roof condition. Hidden cracks in a roof increase the hazard.

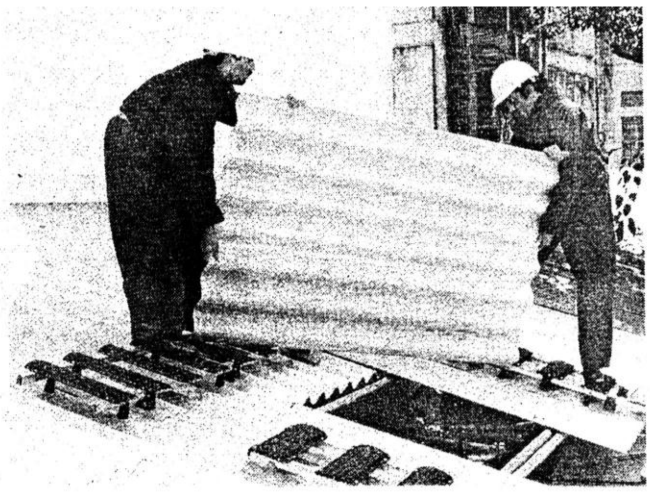
The shape of the roof-flat or sloping with a straight, polygonal or curved profile - affects the fall direction. Water, oil, snow, moisture, chemical, dust and other deposits on roof surface increase fall proneness. High wind and bigger sized sheet in hands cause a roofer to lose his balance.



Flat ladder (roofer's ladder)



Cat ladder or crawling board



Whatever may be the reason, danger of falling toward thereof edge or falling through the roof opening is always there. Smoke or gas coming on the roof or overhead electric power lines also contributes hazards.

Roof work should be pre-planned and only fit and skilled workers should be employed.

Assessment of the nature of work and possible hazards will help to draw safety work permit. Fixed or mobile scaffold, flat ladders (roofer's ladder), sufficient cat ladders or crawling boards side by side, safety belts and safety nets must be provided to each roofer. Anchor points, anchor hooks, bars, wire ropes or other fixing device should be decided. This arrangement must be made first and then only the work may be started under strict supervision. Even for a short duration work, such safety precautions should not be avoided.

Measures should also be taken to protect persons below. Safety cordon, warning notice and fall arrester net can help in this regard. Fall arrester net should be firmly tied as near as possible under the roof to minimise the fall distance.

The workers should be trained for work at heights. Their medical examination is also useful. All walk boards and equipment should be sufficient in number.

Falls through fragile roofing materials : The common, practice of walking along the purling cannot be relied upon. The best way to prevent falls through such fragile materials is to use cat or roof ladders. They should be at least 38 cm wide and should have cross battens at least 3.2 cm thick, fixed not more than 38 cm apart. Safety belts and fall arrester net should also be used as an additional precaution. A permit-to-work system under the control of a responsible person can help to ensure .that the workers are not allowed to work on roofs without taking appropriate safety measures. Rule 68E of the Gujarat Factories Rules requires this provision.

Reinforced AC Sheets are now available in the market. -They are not as fragile as normal AC sheets. The manufacturer 'Eternit Everest Ltd.', New Delhi, names their product as "Everest Lifeguard" and tells it a solution for* 'Safety on Roof Tops". Their literature runs as under:

Everest Lifeguard a high strength fibre cement sheet, with Polypropylene reinforcement strips inserted along precisely engineered locations which run the full length of the sheet in each corrugation, thus providing maximum reinforcement strength with no loss of durability in service.

This product has been developed in conformance of the guidelines issued by UK's Health & Safety Executive, with regard to Health & Safety on roof work (HSG33).

Falls from sides of roof : In case of flat roofs, either the standard railings and toe-boards or a complete barrier to a minimum height of 90 cm should be provided. For sloping roofs, the barrier may be in the form of scaffold boards extending to a minimum height of 40 cm above the roof surface and a guard rail at a height more than 90 cm but not more than 120 cm.

See Chapter-XIV (R.169 to 171) of the Building and other Construction Workers (Central) Rules, 1998 for steep roof.

1.5.10 Safety Work Permit :

A well designed 'Permit to Work System' is always useful to check safety points before hand. Formats used by some good companies are reproduced below:

Format 1 : Safety Work Permit for Working at Height Permit No Date:

Name of the Company	
Plant & Location	
Elevation / Height	

Job Description	
Validity period	

Please answer the following after checking at site. If answer is ‘No’, justify with your remarks :			
Sr.	Check Points	Yes/ No	Remarks, if any
1.	Whethre the job requires erection of scaffolding for making a temporary work platform at high elevation ?		
2.	A standard scaffolding has been erected to make a temporary work platform at required height ?		
3.	Proper ladder has been provided for access to and egress from the work lace at height ?		
4.	Work platforms are provided with hand rails ?		
5.	Static lines provided for hand hold to facilitate safe movement of workers ?		
6.	Safety net (s) provided (Where erection of scaffold or work platform is not feasible or otherwise risk is high) ?		
7.	Proper use of safety belt by all workmen is ensured ? The safety belts are of standard make and inspected ?		
8.	Use of safety helmet and safety shoes by all workmen is ensured ?		
9.	Crawling boards / duck ladders are used for work over slopping roof / fragile roof ?		
10.	Area below has been cordoned off ?		

Issuing Authority (Engineer-in-charge)	Permittee (Site Supervisor)
Signature of the Site Engineer Name ____________________ Company ____________________ Date ____________________	Signature of the Site Supervisor Name ____________________ Company ____________________ Date ____________________
Work completed and this permit expired (Date & Time) :	

Format 2 : Safety Work Permit to work at Height or for Digging

Name & Address of the Company :						
	Work Permit to work at Height or Digging				**Permit**	
					Number	**Date**
Date and Time of Working		Validity of Permit		Location of Work	Initiating Dept.	
From	To	From	To			
Details of Work to be carried out						
General declaration by contactor’s supervisor who will be available at site.						

I hereby declare that the work detailed above will be carried out strictly as per safety precautions (Instructions A or B) mentioned overleaf. I ensure that only those persons who are instructed by me about the safety precautions to be observed and who are trained in such work will do the said work.

I will be available at site throughout the period of work.

_______________	_________________________
Date	Signature of Contractor & Name

Contractor :

Please read carefully and follow instructions (A or B) mentioned overleaf.

Permission Granted for (Tick ✓) :

☐ Working on Fragile Roof / Working at Height **(Refer Instruction A)**
☐ Digging work **(Refer Instruction B)**

Issuing Department		**Receiving Department**	
Name :		Name :	
Signature :		Signature :	
Work completed and this permit expired (Date & Time) :			

Copy distribution : 1st Copy – Issuing Dept., 2nd Copy – Safety Dept. 3rd Copy – User Dept., 4th Copy - Contractor

Instructions A : Permit for Working on Fragile Roof like AC Sheet Roof/Working at Height:

Conditions for Issuing the Work Permit:

1. No person shall be allowed to work on any fragile roof (like AC Sheet Roof) at any height without this permit.
2. The permit is generally valid for the period mentioned 'on the permit and can be extended; but the same permit can be re-authorised by Safety Department.
3. When .the work is on progress, the valid permit must be available with the supervisor who must be available at work.
4. Any authorised person from concerned department or Safety Department will have the authority to stop the work immediately in case he finds that the work is being 'carried out without observing the safety precautions as mentioned below.
5. The permit is NOT VALID if not authorised by the Safety Department and the declaration is not signed by contractor's supervisor who will be at site.
6. Safety department can revoke, cancel or renew this permit with valid reasons.

Safety Precautions to be followed:

Following safety precautions will be followed by the contractor and his workmen before, during and after the work on AC sheet roof/at height. No person should be allowed to work on fragile roof/at height unless the following conditions are fulfilled.

1. Suitable and sufficient access ladders, duck ladders, cat ladders, crawling boards etc. shall be used and they should be securely fixed or supported. Such working aids are to be inspected by executing department prior to usage.
2. For high risk (more height) fall arrester net shall be firmly tied as near as possible underneath the roof or plane of working.
3. Nobody shall be allowed to go on the AC roof without a valid permit and according to conditions mentioned therein, with the Site Supervisor.
4. Safety belts in good condition and approved by safety department should be given to the concerned persons and they should be trained and supervised to wear them and fasten them securely and correctly with a fixed immovable structure.
5. No worker shall be allowed to step directly on any part of AC sheet roof.
6. No tools/materials shall be left on the roof after each day's work is over.
7. Electrical power supply, if it concerns place of work, shall be isolated.

Instructions B : Permit for Digging work:

Following Safety precautions will be followed by the contractor and his workmen before, during and after the work of digging. No person shall be allowed digging work unless the following conditions are fulfilled.

1. Nobody shall be allowed to undertake any digging work without this Valid Permit, available with the Site Supervisor, who will produce it on demand. -
2. Contractor shall instruct his workers to work strictly as per safety instructions given herein and care shall be taken to ensure no damage to electrical cables and piping underground.
3. Isolation of electric supply, water/oil/gas supply's per the direction of concerned department shall be carried out.
4. Permission of Electrical Maintenance and other concerned 'Department must be obtained before undertaking any digging work.
5. Fencing and Indicators shall be placed around the trench and red lanterns shall also be placed at night, if necessary.
6. Loose excavated material shall be remove< by pei son using rubber gloves.
7. No tools shall be left after each day's wor is over.
8. The Supervisor must be available at sit during the period of work.

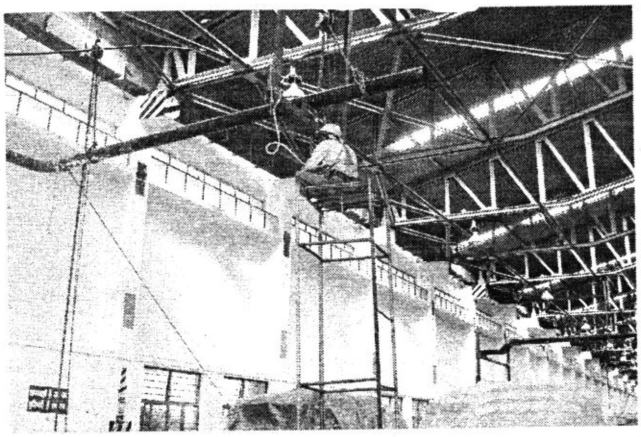
1.5.11 General Precautions while Working at Height

They are as under -

1. Cut off power in nearby electric lines to avoid shock and fall.
2. Do not lift or carry excessive load so as to loose balance and fall.
3. Tools should be attached by lanyard to the belt or garment to prevent their fall on others.
4. Safety helmet, shoes, safety belt, respirator and other PPE should be worn as per need.
5. Keep the work floor always dry, clean and well protected. The floor should be checked for fragility, crack and its soundness to carry load. Non fragile metal sheets or reinforced AC sheets are preferable.
6. Know safe means of access, emergency staircase, fire extinguisher, first aid box and other device like aerial platform, rope ladder etc. before starting the work.

7. Pre-employment and periodic medical examination of workers to check their suitability for working at height. Workers suffering from balance disorders, vertigo, epilepsy, blackouts etc. should not be employed or continued to work at height.
8. Trained Workers: Safety belts, harnesses and lanyards are to be used in conjunction with permanent anchorage points. Workers should be trained to know how to check, wear and adjust before they start work and how to connect themselves to the structure or safety line.

Workers can also use mobile access equipment i.e. mobile elevating work platforms, cradles and mast platforms. All users of such equipment should be trained and competent to operate it. They should also be aware of emergency and evacuation procedures so that if, for example, the power to platform fails, they know what they should do.



It is essential for employers to implement safe working procedures for working at heights.

2 WORKING IN A CONFINED SPACE

Work in vessels and tanks below ground in pits, cellars and basements or inside confined spaces such as silos, tanks, vats, vessels, boilers gutter etc., pose danger and always require permit to work system.

2.1 Meaning and Hazards of Confined Space :

Clause 2(0), Sch-19, rule 102, GFR, defines 'confined space' as any space by reason of its construction as well as in relation to the nature of the work carried therein and where hazards to the persons entering into working inside exist or are likely to develop during working.

Confined Space is also described as a place which

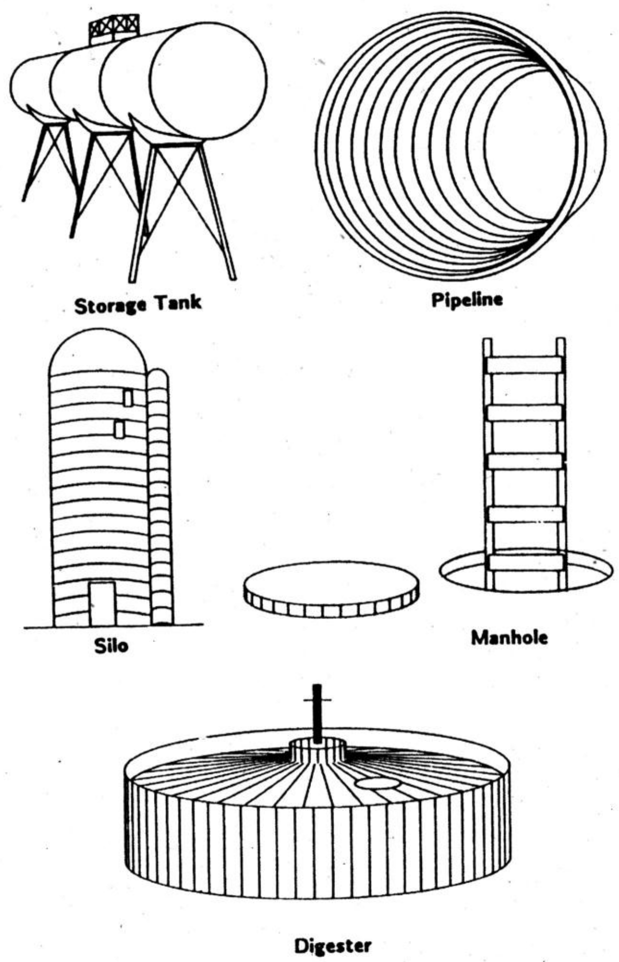
1. Is mostly enclosed and partially open.
2. Is at atmospheric pressure and temperature.
3. Has limited or restricted openings for entry and exit.
4. Is not designed or intended for normal place of work (i.e. not for long time worker occupancy).
5. Has unfavourable natural ventilation due to stagnant air, no free air movement, oxygen deficiency or enrichment or nitrogen atmosphere.
6. Has contaminated air with toxic or / and flammable gas, dust etc and
7. May cause engulfment (swallowing) in unstable or loose material.

Examples (Types) of confined spaces are -

1. Storage tank
2. Process vessels / Reaction Vessel

3. Pressure Vessels
4. Boilers
5. Tank cars (trucks)
6. Tank wagons
7. Digester
8. Wells / bores
9. Under floor/ Floor opening
10. Sumps
11. Pits
12. Silos
13. Pipes
14. Ducts
15. Gutters
16. Tunnels
17. Sewers
18. Vats
19. Bilges
20. Shafts
21. Go-down of grain, sulphur, cement, clay and similarly loose material
22. Roof voids / Gap between roof and false ceiling.

See also Part 3.13 of Chapter 2



Examples of Confined Spaces

Hazards of Confined Space can be classified as-

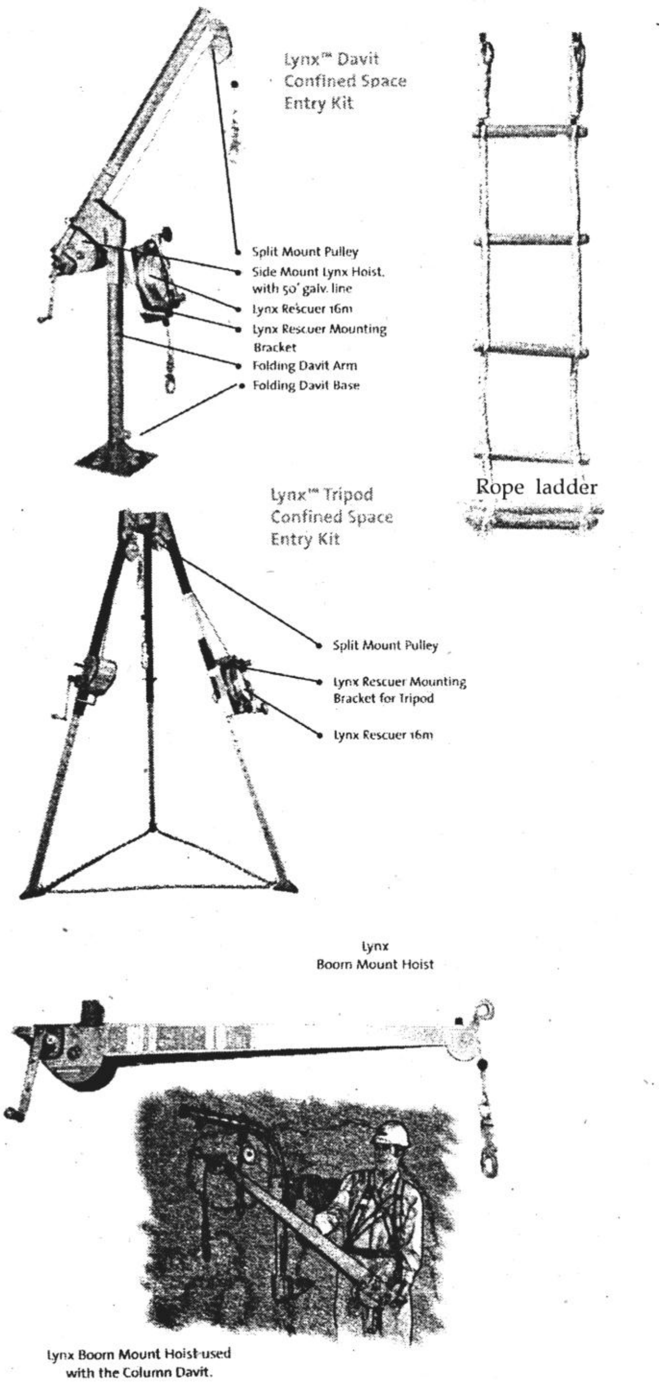
1. Poor lighting and ventilation.
2. Oxygen deficiency.
3. Contamination of toxic and/or flammable gases.
4. Unexpected activation of machinery or flow.
5. No way or no time available for exit.
6. Engulfment (burying) in loose material.
7. Non specific work practices.

Other hazards are suffocation, burning, poisoning, explosion, drowning, freezing, crushing, entrapment, scalding, stroke, heat stress, radiation, physical trauma, injury by moving machinery, slipping or falling etc.

Many fatal and serious accidents have occurred while working in a confined space. Three reasons flammable air mixture, toxic gases and oxygen deficiency - are found responsible for such accidents. Tanks (vessels) with top cover open but all other sides closed, should be considered as a confined space, because, in such situation persons working inside have to face direct fire, explosion, or toxic exposure and have no other way to run away except the only way of their entry. Therefore doubtlessly and as per above statutory definition, such situation/condition is a confined space. One worker died due to solvent fire, one died due to chloroform vapour and two died due to nitrogen (oxygen deficiency) atmosphere in such confined spaces.

Safety equipment for working in a confined space.

Following equipment are useful for working safely in a confined space.



Safety equipment useful for working in a confined space

2.2 Vessel Entry Permit :

Tanks, vats, pits, sumps, vessels, floor opening etc. should be protected by guard rails or cover. Fixed ladder with handrail if possible, should be provided to step down safely. Portable (rope) ladder may be used while working inside a tank or vessel for temporary work.

Statutory provisions for confined space entry are already stated in foregoing Part 1.3 of this Chapter. Other precautions are:

1. Check the concentration of toxic or flammable gas, dust, vapour etc., by a gas detector. Oxygen content should also be checked for safe proportion. It should be >18%.

2. Air line or self contained breathing apparatus and safety belt are essential.
3. Sump pumps with flameproof electric or pneumatic motors and air extraction fans (spark proof) and exhaust ducting to remove heavy vapours are necessary.
4. Complete isolation of the vessel, cleaning, purging and ventilation of the vessel, inspection and testing, safety permit and all rescue arrangements must be done before such work and only a trained worker will work under constant help and supervision.
5. Latest safety and rescue systems should be used. Winch arrangement connected with the worker's harness is useful to lower and pull out quickly. Handfree communication system is available to keep the worker in the tank in constant touch with the supervisor outside. Hand operated clutch, cord and chair assembly can be used to lower the person while working at height or depth.
6. Bottom drain valve and other nozzles should be kept open to allow good ventilation and fresh air in a vessel or tank

Refer Part 16.2 of Chapter-18 for more details of safe entry into a vessel.

Before allowing vessel (confined space) entry permit, it is necessary to carry out hazard assessment of the space. Therefore two types of formats are giver below for use. Necessary changes as per specific requirement should be incorporated.

Format I - Confined Space Hazard Assessment

Plant No.		Description	
Access/ Egress		Ladder State	Scafold Other.
Access Security	Padlocked None	Key locked Other	Simple latch
Impediments to access/ conduct of wok		Plant layout Manual handling None	Dimensions Ergonomics aspects Other
Hazards			
Potential Hazards (if yes, must be monitored)	Oxygen levels Explosive atmospheres	Carbon monoxide Other	Hydrogen sulphide
Cleaning in confined space		Chemical High pressure water None.	Steam Water Other
Hazardous substances stored ? Yes No. (if yes, list names and indicate need for monitoring.		Substance Name	Monitor ?
Illumination		Acceptable	Additional illumination required
Ventilation		Acceptable	Additional ventilation required.
Temperature extremes	Hot	Cold	None
Lockout tag out required Yes No (if yes, indicate energy sources)	Electrical Natural gas Steam Stored energy	Hydraulic Pneumatic Water Static	

Control Measures			
Personal protective equipment required (if hazardous substances present check MSDS for additional requirements)	Escape unit Lanyard retraceable Gloves-type Eye protection – type Hearing protection-type Respiratory protection-type	Industrial clothing –type Communication equipment- type Lighting-type Hard hat Harness	Safety boots Safety line
Persons in confined space	Maximum		Minimum
Emergency response procedures			
Emergency response equipment required.			
Assessor signature		Assessment data	
Manager responsible for confined space		Date	
Copies distributed to		Comments	

Format 2 – Confined Space (Vessel) Entry Permit

Plant No.		Description	
Reason for entry		Inspection Maintenance	Cleaning Other
Details			
Requested by			Date
Control measures.			
Hazard Assessment Number.		Assessment Date.	
Lockout tagout required. Yes. No. (if yes, Lockout permit must be attached).		Hot work required ? Yes. No. (if yes, Hot work permit must be attached).	
Oxygen levels % (must be 19.5 – 23.5%)		Flammable gases % LEL (must be <5% LEL).	
Other gases …………… ppm …………… ppm		Other atmospheric contaminants.	
Personal Protective Equipment At risk assessment. Changes.		Provide details of and reasons for changes to PPE requirement here.	
All persons entering space and stand by persons have been trained.		Yes	No
All persons entering space and stand by persons know emergency procedures ?		Yes	No
Stand by persons			

Issue of Permit to Work (Authorization to enter)

I have reviewed the risk assessment for this space and understand the hazards and control measures required. This confined space is safe for entry to do the work described above provided all precautions are fully observed and that isolation points have been checked and secured.

Approval signature	Date.	Time
This permit to work is valid until (give date and time)		

Persons entering confined space

I have been instructed on the control measures to be observed and fully understand the precautions to be observed and will observe them while in the confined space.			
Name	Date	Time	Signature

Persons leaving confined space

Name	Date	Time	Signature

Withdrawal of Permit to work

All persons and equipment accounted for	Yes	No
Equipment checked and restored correctly ?	Yes	No
Signature (must be same as approval).	Date	Time
Comments about the work		

3 WORKING UNDERGROUND :

Working underground has hazards similar to working in a confined space. Therefore all precautions including entry permit mentioned in part 2.2 above should be followed.

Under ground work includes digging also. Therefore format 2 and instructions B mentioned in part 1.5.10 should also be considered.

Hazard assessment of underground atmosphere is most important. Oxygen level, measurement and removal of other gases (e.g. HS, CO, methane etc) by exhaust ventilation, artificial lighting (flameproof if necessary), necessary ladders, supports, water evacuation, safety harness, helmet, respirators, safety shoes etc. are necessary as per hazard assessment report.

See also Part 5 of Chapter 22.

4 WORKING AT THE SAME LEVEL

The common causes for such falls are slipping or tripping due to floors badly maintained, floor opening, unguarded machinery, obstacles on floor, oily material, poor lighting, poor vision or health, defective footwear, running or jumping and influence of drugs, alcohol or fatigue. Remove these defects, put guards/ barriers if necessary and warning notices as a last resort.

5 SAFETY AGAINST FALLING BODIES

Instead of persons falling, many times falling bodies hit the persons and cause accidents. Measures for safety are:

1. Wear helmet or hard hat, safety shoes and protective clothing necessary.
2. Never stand or walk under suspended load.
3. Never throw any things down from aloft or - height.
4. Place tools and materials in stable and safe position so as not to fall. Use a tool box or paint pot secured to a ladder or platform by a hook.
5. Take care in staking materials and ensure that

EXERCISE

1. Explain, State, Mention or Discuss -

1. Types of fall accidents.
2. Main causes of fall accidents and their preventive measures.
3. The kinetic energy of a falling body.
4. Statutory provisions to prevent fall accidents.
5. Which are the areas where a worker has to work at height and what precautions are necessary to work safely?
6. Usefulness of Building and other Construction Workers Act and Rules for safety while working at height or prevention of accidents due to falls of persons and materials.
7. Types of misuse of ladder and safety precautions to avoid them.
8. General requirements of scaffolding
9. Hazards and safety measures while working with -scaffolds.
10. General requirements of a safety belt.
11. Types of safety belt.
12. Hazards and safety precautions while working on a slopping or fragile roof.
13. Need and check points of a safety work permit for working at height OR in Depth.
14. General precautions while working at height.
15. The meaning and hazards of a confined space.
16. Types and hazards of a confined space.
17. Variety of confined spaces and safety measures while working in any two of them.
18. Safety while working underground.

2. Write Short Notes on

1. Incidence rate of fall accidents.
2. Indian Standards for safety of working at height and prevention of fall accidents.
3. Design aspects of stairways OR Floors.
4. Safety requirements of floors and platforms.
5. Types of ladders and their salient features.
6. Design aspect of a scaffold.
7. Pole type scaffold OR Swinging Scaffold.

8. Boatswain's chair.
9. Dismantling of a scaffold.
10. Fall arrester or Anti fall device.
11. Crawling board.
12. Conditions in a permit for digging work.
13. Hazards of working in a confined space.
14. Examples of confined spaces.
15. Engulfment.
16. Working in a sewer or gutter.
17. Main hazards of working underground.
18. Non-slip devices for ladder feet.
19. Limitations of ladder.
20. Types of anti fall systems.

3. Explain the difference between -

1. Types of fall accidents and causes of fall accidents.
2. Types of falls of persons and types of falling objects.
3. Stairways and ramps.
4. Pole (putlog) type scaffold and Outrigger scaffold.
5. Rolling Scaffold and Swinging (hanging) Scaffold.
6. Outrigger scaffold and Suspended scaffold.
7. Hazards of working at height and working in a confined space.
8. Safety precautions while working at height and those while working in a confined space.

4. Comment on the following explaining whether it is true or false?

1. Most of the falls from height (roof) prove fatal.
2. Outrigger scaffold should be the last resort if other types of scaffold are not possible.
3. Guard rail and toe board are not necessary on scaffold.
4. While working at height safety belt is fully sufficient, no other arrangement is necessary.
5. Boiler is a confined space but pressure vessel is not.
6. Tank trucks or tank wagons are not a confined space.
7. Storage tank is a confined space but a ball digester in a paper mill is not.
8. Confined space has many types of hazards.

Reference and Recommended Reading

1. Safety in working at Heights, issued by DGFASALI, Sion, Mumbai - 22.
2. Industrial Hazard and Safety Handbook, King and Majid, Butterworth.
3. Indian Standards mentioned in this Chapter.
4. Occupational Safety Management and Engineering, Willie Hammer, Prentice-Hall.
5. Encyclopaedia of Occupational Health and Safety, ILO, Geneva
6. Complete Confined Spaces Handbook by John Rekus
7. Elevated Work Platforms and Scaffolding: Job Site Safety Manual by Matthew J. Burkhart, Michael McCann and Daniel M. Paine
8. Fall Protection and Scaffolding Safety by Grace Drennan Gagnet
9. Slip and fall Prevention: A Practical Hahdbook by Larry R. Collins and Thomas D. Schneid
10. Introduction To Fall Protection, Third Edition by J. Nigel Ellis

CHAPTER – 17

Hand Tools and Portable Power Tools

THEME

1 STATUTORY PROVISIONS

Section 36A of the Factories Act states that portable electric appliance (any tool, equipment or instrument) when used in any confined space (tank, vat, chamber, pit, pipe, flue etc.), shall be of low voltage up to 24 Volt only, or other safety device like ELCB should be provided.

If inflammable gas, fume or dust is likely to be present in such confined space, portable lamp or light should be of flameproof construction.

Clause (5), Part HI of Schedule XIX, Chemical Works u/r 102 of the Gujarat Factories Rules requires all tools and appliances for work in flammable area of non-sparking type. Similar provision is also required under clause (5), Schedule XXI, Solvent Extraction Plants, under the same rule.

2 INDIAN STANDARDS

Some IS are : Safety procedures in hand operated tools §235 (PED5), SP-53. Tools - for hand, footwear 6053, handles wooden 620, handling device 4676, mason's 1630, metal cutting 10097, metal forming 6652, mining - tungsten carbide 4005, non-sparking 4595, planning 6075, 8842, threading 8778, pneumatic 5651, portable - motor operated 4665, rotating 1850, shanks - taper and automatic changers' 11173, numerically controlled machine tools 11172, steel high speed 7291, turning and planning 1983, universal, test chart 3080.

Tool and die - hot work 3748, cold work 3749, press sets of, guide posts 7664, broaching 7773.

See Part 2.2 of Chapter-15 and Part 3 of Chapter25 also.

3 HAND TOOLS

No work is finally possible without hand-held or hand operated tools. Such tools are of many types, having many purposes and operated by hand only or by some energy e.g. electric, pneumatic, hydraulic etc.

3.1 Causes and Control of Tool Accidents:

Causes of tool accidents and their safety aspects including ergonomic design are important -

3.1.1 Main Causes of Tool Accidents:

Table 5.8 in Chapter-5 states that in India, injuries due to Hand Tools were 9 fatal and 10571 non-fatal i.e. total 8.25% in 1990 and 5 fatal and 3314 non-fatal i.e. total 5.47% in 1991.

Table 5.20 states 9 & 12 fatal accidents due to hand tools in Gujarat in 1996 .& 1997. This comes to 4.91% & 4.89% respectively.

The last raw of Table 5.22 indicates that hand tool accidents (Causation No. 124) were 4.52% (710 out of 15683) in Gujarat in 1994. Thus hand tools accidents vary from @ 4 to 8% each year which need to be controlled.

USA figures of deaths due to cutting or piercing instruments or objects were 103, 108 and 132 in the year 1994, 1993 and 1992. Percentage wise these were 0.11, 0.15 & 0.15 respectively. (Accident Facts, 1997, NSC).

The causes and effects of hand tools accidents are eye injuries due to flying chips from tools, puncture wounds and infections, cut injuries due to knives, chisels and hammers, bone fractures due to defective or slipping wrenches and scratches due to scrap etc., cutting of fingers, tendons and arteries, contusion etc.

Poor maintenance, incorrect tool, wrong use, carelessness, bad storage and poor material are main causes of tool accidents.

3.1.2 Prevention & Control of Tool Accidents:

The main control measures are:

1 **The right tool for the right job:** Wrong methods are: To use file instead of pry, wrench instead of hammer, pliers instead of wrench etc. This may cause accident. Therefore it should be avoided.

2 **Tools in good condition :** Examples of poor condition are : Hammers with loose handles, screw drivers and cutting tools with broken points or broken handles, wrenches with cracked or worn jaws, dull saws, and flexible electric cables with splint insulation, broken plugs, unearthed ground wire etc. Such conditions should be removed.

3 **Tools used in the right way:** Wrong ways are: Screw drivers applied to job (e.g. to open a lid, to remove bearing), knives pulled toward the body and failure to ground electrical equipment. Tools should be used in right way.

4 **Tools kept in a safe place and safe way:** Unsafe practices are: Tools kept overhead so as to fall; chisels and other sharp tools kept in pocket or left in tool boxes with cutting edges exposed. They should be kept in a proper way.

5 **Good housekeeping for orderly layout and cleanliness:** Haphazard lying of tools anywhere, leaving tools at the workplace after completion of the job, slippery surface not cleaned, tools kept in aisles or walkways etc. are common causes of tool accidents. Tools should be kept orderly.

The supervisors and workers should be trained

1. To wear safety goggles, face shield, helmet etc as per requirement.
2. To select the right tools for each job and their right use. To return the tools after use.
3. To guard, inspect, repair and maintain tools in safe condition.
4. To use the proper storage facilities in the too room and on the work place.
5. To put the tools in such a way that they can be readily available.
6. To scrap and replace the tools when worn.
7. To check out tools at cribs.
8. To store in safe condition when not in use.

3.1.3 Ergonomic Design of Hand Tools

Ergonomic design of hand tools takes into consideration that they should :

1. Effectively perform the intended function.
2. Be properly proportioned to the dimensions of the user.
3. Be appropriate to the strength and endurance of the user.
4. Minimise user's fatigue. It should be comfortable to him.
5. Provide sensory feedback.

Some biomechanical factors to be considered in tool design are grasp, handedness (left or right, single or double), hand strength, sex and clothing.

Criteria affecting handle design are its shape, diameter, length, angulations and texture. Specific criteria are - diameter, shape, weight, section, length, angulations of and placement of handle for hammer.

Screw drivers, pliers, saws and power tools are important for ergonomic design.

See also Part 3.4 of Chapter-24.

3.2 Types and Safe Use of Hand Tools:

See Fig. 17.1 for different types of hand tools.

Main types of hand tools are as under -

(A) Metal Cutting Tools :

These are chisels, stamping and marking tools, tap and die work, hacksaws, files, hand snips and cutters.

Factors of selection and safe use are : Materials to be cut, size and shape of the tool, depth of cut, sponge rubber shield or combination of rubber hand grips and shields on hammer struck tools, use of chisel holder or tong, safety goggles, vice, wrench, right type of file with smooth handle, lubrication on cutters etc.

The flat **chisel** should have its cutting edge slightly convex. All chisels (flat, cold, diamond point or cape type) should be strong enough so as not to bend when struck. Striking face of the hammer should be slightly larger (9 mm by dia) than the struck face of the chisel. Bull chisel should be held by tongs or chisel holder to save the holder from injury.

Stamping and marking tools should be held by tool holder to keep fingers away from the tool being struck.

In **tap and die work,** hands should be kept away from broken tap ends and threads being cut.

Hack saws should be properly tightened in the frame to prevent buckling and breaking. Select proper blade (teeth per inch) for the proper metal (hard or soft) to be cut. Pressure should be applied on forward stroke only. Cutting speed of 40 to 60 strokes per minute is proper.

Selection of correct file for the job can prevent injuries, increase production and file life. A file should

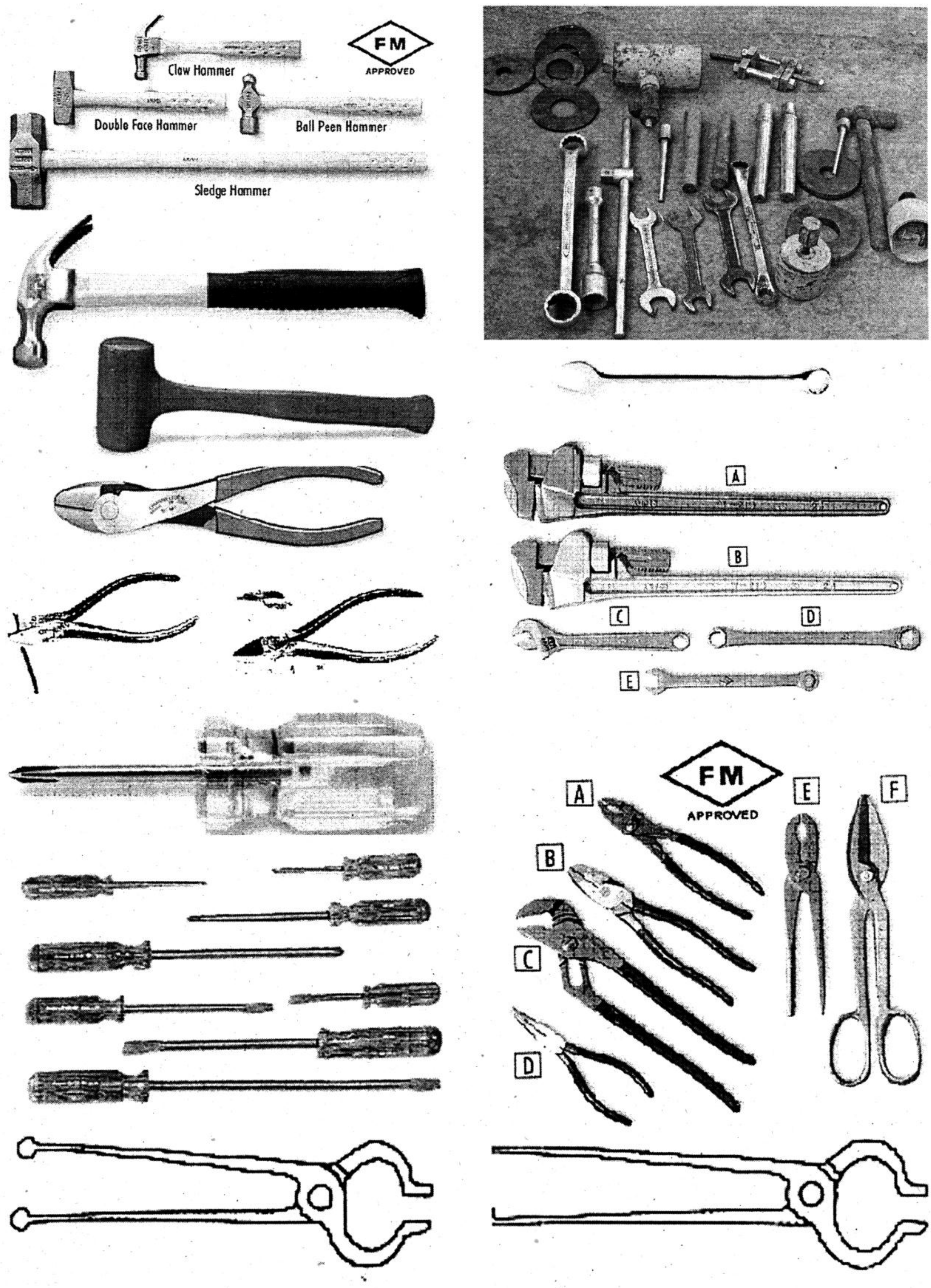


Fig. 17.1 Hand Tools

not be hammered or used as a pray. It should not be used as a punch, chisel or other tool because the hardened steel may fracture in that way.

Jaws of hand snips should be kept tight and well lubricated. Do not hammer on the handles or jaws of the snips. Safety goggles and leather or canvas gloves are necessary.

Cutters should be used to cut at right angles only. They need frequent lubrication and should not be used as nail pullers or pray bars.

(B) Wood Cutting Tools :

These are wood chisels, saws, axes, adzes and hatches.

Factors of safe use are : Proper method of holding and using the tool, splinters free handles, nail detection, sheath or metal guard on axe blade, use of safety goggles, sharp and proper cutting angle. Do not drop the tools.

The wood to be cut should be free of nails to avoid damage to the cutting edge. A wood chisel should not be used as a pry or wedge, otherwise the hard steel may break.

Proper saw (crosscut or ripping) should be selected. When not in use, saws should be wiped off with an oily rag and kept in racks or hang by handle. Nails should ,be cut by metal cutting saws.

Axes and hatches are designed to cut, trim or prune trees and soft wood. Their cutting edges should not strike against metal, stone or concrete. A narrow - bladed axe is used for hard wood and a wide axe for soft wood. Safety shoes, goggles and thick pants should be worn while using an axe.

Adzes are hazardous tools and should be used by trained workers only. Safety shoes, shin guards and safety goggles are necessary. When not in use, it should be set aside in a safe place with its cutting edge covered or left stuck in the timber.

(C) Material Handling Tools :

These are crow bars, jacks, hooks, shovels and rakes.

Factors of safe use are : Proper size and type of the tool and its handle, solid footing and' lubricating of jack, shielded point of the hook, trimmed edges and polished handles of shovels.

A **crowbar** has a point toe to grip the object to be moved and a heel to act as a pivot or fulcrum. Sometimes a wooden block may be placed -under the heel to prevent the crowbar from slipping and injuring hand.

Hooks should be sharp so that they should not slip when applied. Handles should be strong and properly shaped and attached.

Shovels should be used by proper leg positions so as not to lose balance. Edges should be trimmed and handles without splinters.

(D) Hand feed tools :

To protect hand and fingurs while working with power presses, rolling mills, press brakes, banding machines and other machineries and also working with hot matels, hand feed tools are used. They are shown in fig. 17.2.

(E) Torsion Tools:

These are adjustable wrenches (spanners), pipe wrenches, pipe tongs, machine wrench, torque wrenches, socket wrenches, open end or box wrenches, pliers, tongs, special cutters, nail band crimpers and screw drivers.

Factors of safe use are : Sharp jaws of wrenches, inspection of adjusting nut of the wrench, correct size of the wrench and not to change its dimension, insulated handles of electricians' pliers and screw drivers and screw driver not using for other purposes. A screw driver tip must be properly ground. The user should not lose balance on slipping of tool or the job.

Box and socket wrench (spanner) completely encircles the nut, bolt or fitting and grip it at all corners as opposed to the two corners grip by an open-end wrench. They cannot easily slip.

Wrench capacity should not be overloaded by using pipe extension on the handle or striking the handle as normally bus drivers do. For heavy duty work, sledge-type box wrenches are available. Penetrating oil (kerosene) should be used first to loosen tight nuts.

The use of the wrong size wrench can round the corners of the bolt or cause slippage and. make its subsequent use difficult. Makeshift approach is not good.

Adjustable wrenches should be used for light duty jobs where no fixed spanner is available.

For the reason of safety, wrenches should be pulled toward the self and not pushed.

Pipe wrenches should be prevented from slipping and falling. Its adjusting nut should be checked frequently. If it is cracked, the wrench should be withdrawn from the use. A pipe wrench should be used for pipes and their fittings only and not for nuts and bolts because their corners can break the teeth of the wrench, thereby making it unsafe to use later for pipe work. It should also not be used for soft metal (brass, copper) valves or fitting which can be crushed or bent out of shape.

Pliers are meant for gripping and cutting operations and should not be used as wrenches. A

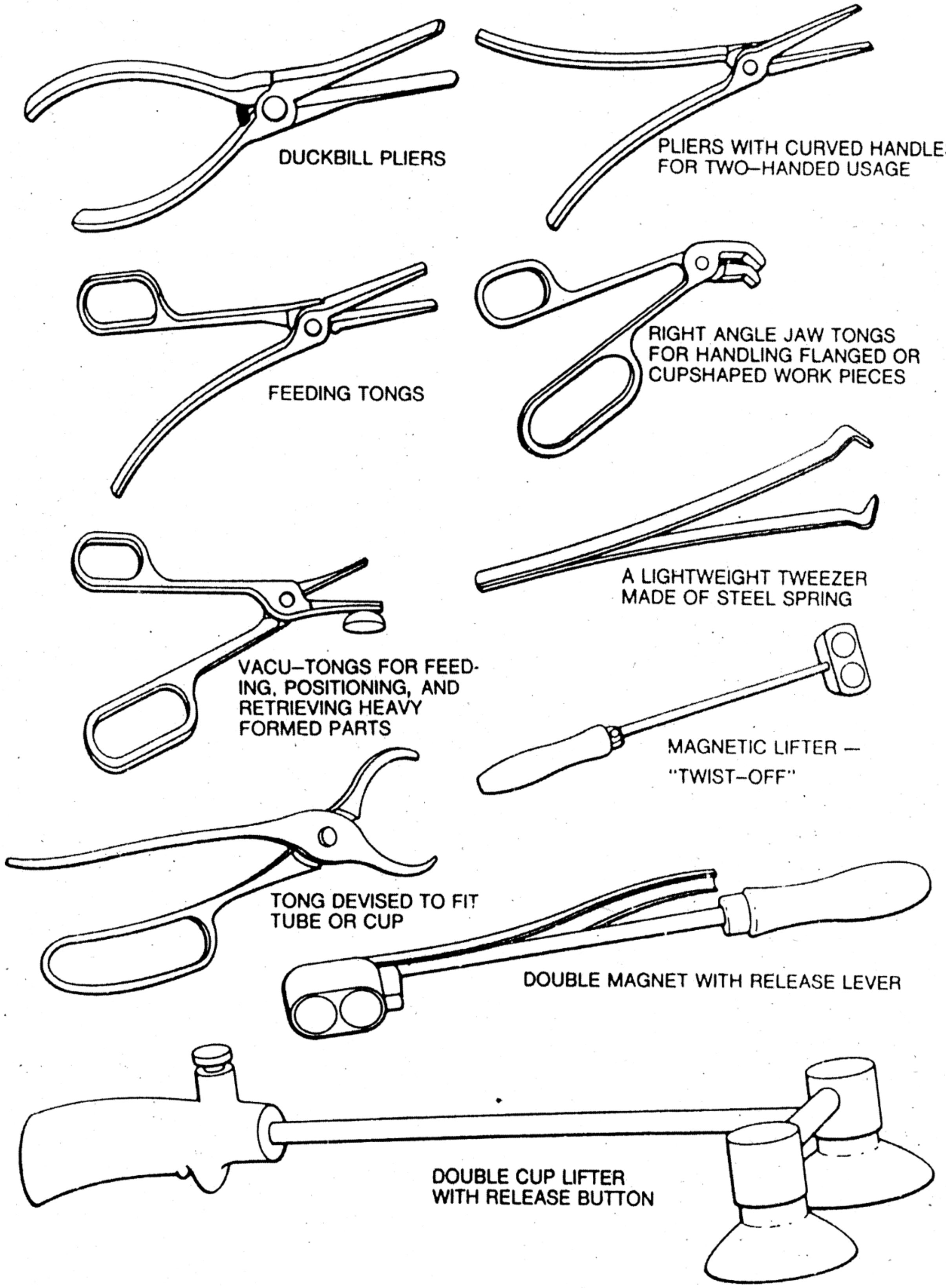


Fig. 17.2 Examples of hand feed tools (from OSHA 3067).

guard cover on cutting edge of side-cutting pliers can prevent flying short ends. Pliers for electrical work must be insulated and simultaneous use of electrician's shock-proof gloves is also necessary.

Pullers are used to pull out gear, wheel, pulley, bearing etc. from a shaft. Prybars and chisels should not be used for this purpose.

Screwdriver tip must be properly ground to fit the slot and it should be of the correct size for the head. Handle should not be hammered. For electrical work, handle should be insulated. Screws should not be overtightened to avoid slipping.

(F) Shock Tools:

These are hammers, sledge hammers, riveting hammers, carpenter's or claw hammers. The handles should be smooth and of proper size.

(G) Non-Sparking Tools for Hazardous area :

Such tools of non-ferrous (Beryllium, copper alloy, brass, copper, lead, plastic, rubber) materials are used where flammable gases, volatile liquids and explosive substances are stored or used. They should be kept free of picked up foreign particles to avoid friction sparks.

Hazardous area classification (Part 8.1 of Chapter II) should be known first before selecting hand tools. In most hazardous area where high risk of fire or explosion exists, non metalic ie. wood, rubber or plastic tools should be used if possible and proper earthing of equipment should be ensured. There should be flameproof electric lighting arid if hand lamp is to be used, it should not be of more than 24 V. Working in day lighting should be preferred.

For use of welding/cutting tools, statutory provisions (viz. Sch. 24 of GFR) should be strictly followed.

Necessary PPE for working in hazardous area should also be used.

They cannot be used to apply heavy stroke. Therefore careful use is necessary. It should be properly selected.

(H) Miscellaneous Cutting Tools :

Planes, scrapers, bits, drawknives, ice picks and brad awl are used for special purposes.

Knife accidents are many. A handle guard or finger ring on the handle of knife and the cutting stroke away from the body are desirable. Knives should be carried over the right or left hip toward the back. This will prevent severing a leg artery or vein in case of fall. Knives should not be kept mixed with other tools. Knives should not be used in place of screwdrivers, can openers or ice picks.

All such tools should be kept sharp and in good condition. When not in use, they should be placed in a rack on the bench or in a tool box in such a way that will protect the user as well as the cutting edge.

Carton cutters are safer than hooked or pocket knives for opening cartons as they eliminate deep cuts that could damage inner contents.

While walking or climbing on ladders, workers should use a strong bag, bucket, tool hoist belt or pouch to hold tools safely and to keep both hands free for safe moving and working. Sharp tools should not be put in pockets. Tools shall never be thrown on ground. Tools should not be put on vibrating or slippery overhead surfaces, ladder step, scaffold plank, overhead piping or part of any structure or machine from .which they can easily fall or hurt.

While giving tool to another person, the handle should be toward the receiver. While turning around, care should be taken not to strike others.

Misuse of hand tools can cause injuries. Use of hand tool with power driven machinery (e.g. lathe) should be controlled. Training is necessary for their safe handling and use. Use of safety goggles and setting up a shield or screen to prevent injury to others from flying particles, sparks, excessive light, radiation etc. are also required.

Indian Standards should be followed for design, selection, use and maintenance of above tools. See Part -2.

3.3 Centralised and Personal Tool Issue System :

The main advantage of such tool control is the uniform inspection and maintenance of tools by a trained man. It facilitates the effective records of tool failure, accident causes and suggestions for improvement. It provides positive control than scattered storage. Tools are well maintained and less exposed to damage, deterioration .and falling hazards.

The central tool control room attendant can advise and issue the right type of tool, ask to return the damaged or worn tool and encourage the safe use of tools. He can also suggest the appropriate type of personal protective equipment at the time of issuing the tool and make arrangement to get clean and to well maintain the tools after and before issue.

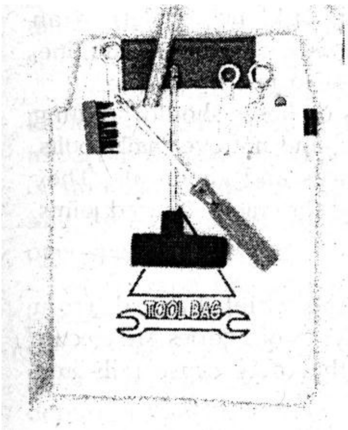
Methods of service, repair and reconditioning should be established. Supervisors should frequently, at least weekly, inspect all tools and remove from service those found damaged. A checklist of inspection can also be designed and used.

It is the employer's responsibility to see that the employees are provided with and use the safe tools in safe methods.

3.4 Purchase, Storage and Supply of Tools:

Careful purchase of hand tools can eliminate hazards from beginning. Standard (IS & others) and approved type of tools should be ordered for purchase. Material of construction, quality, durability, ergonomic design, good handle and insulation, effective cutting edge and electrical safety with electrical tools are some of the points for better selection. Purchase of tool boxes, chests, cabinets, belts and pouches also needs attention. In-charge of a central purchase department should fix the criteria or guidelines for best quality tools. Advice of the safety committee and experienced supervisors and workers should also be taken.

Storage of tools should be in a dry cool place and away from any chemical effect. Tools should be kept in a tool box. Proper cupboard, rack or shelves should be used to put tool boxes. Shelves may be movable so that workers can reach all sections to get their tool boxes out.



Tool boxes should be used to put and carry the tools. A tool box should have handle, catch or a hasp and locking arrangement. Bigger tool boxes having more drawers or trays are called tool chests. Mobile tool cabinets are bigger tool chests and move on wheels. Depending on size, weight and number of tools, proper type of tool box, chest or cabinet should be selected.

Supply of tools may be from a central tool room or through supervisors on need-base system or allotted to the worker to keep with him in his tool box. It should be ensured that the tool should be of good quality and in safe and good working condition. Supply includes replacement of damaged or worn tools. A record of purchase date, service condition, repair and maintenance can be useful in this regard.

Tools should be in sufficient number so that it can be supplied or replaced individually and work is not suffered because of any waiting time. If this is not possible, working time of the tool should be so scattered and planned to minimise the waiting period. Time of supply should be during working hours and suitable to the workers.

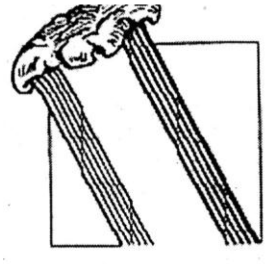
3.5 Causes of Tool Failure :

They are : overheating or under heating of the forging of steel when it was hardened, cracks from improper forging, improper tampering, failure to relieve stresses in forging, improper quenching, incorrect angle of cutting edge or steel of poor quality.

Defects of these types will be found in tools of inferior construction, which, because of breakage and inefficiency, are more expensive in the long run than are tools of the best quality obtainable.

3.6 Inspection, Maintenance and Repairs of Tools :

The tool room attendant or tool inspector should be qualified by training and experience to pass judgement on the causes or defects of tool failure stated above and condition of tools for further use. No dull or damaged tools should be given for work.



Efficient tool control requires periodic inspection of all tool operations. Responsibility for such periodic inspection should be placed with a top man, preferably the department head and should not be delegated by him..

Hand tools receiving the heaviest wear, such as chisels, wrenches, hammers, sledges, star-drills, blacksmith's tools and cold cutters require frequent maintenance on a regular schedule.

Repair facilities require work benches, vices, hardening or tempering furnace or forge, tempering baths, goggles, repair tools, grinders, fasteners and good lighting. Enough stock should be maintained to replace and issue safe tools.

3.7 Tempering, Safe Ending, Dressing and Handles of Tools :

Tempering of Tools: Hammer-struck and striking tools (chisels, stamps/punches, cutters, hammers, sledges and rock drills) should be made of carefully selected steel and heat-treated so that they are hard enough to withstand blows without mushrooming excessively and yet not be so hard that they chip or crack.

For safety, it is better that shock tools, some of which can be dressed frequently, be a little soft rather than too hard, because a chip may fly from an excessively hard tool without warning when the tool is struck with a hammer or sledge.

Forming and tempering of tools is a skilled operation. Before heat-treating any tool, the exact analysis of tool or recommendations for its proper heat treatment should be obtained.

Safe-ending of Tools : Hammer-struck tools, such as chisels, rock drills, flatters, wedges, punches, cold cutters and number dies should have heads properly hardened by a qualified workman. The hazard of burred heads can be reduced by safe-ending the tool. This can be quickly and economically achieved by grinding or flame cutting a shoulder recess about 1/8 inch wide and 1/4 inch deep into the tool head and then bronze-welding it. The proper base-metal temperature for bronze-welding is 1600° to 1700° F. The correct temperature is indicated by a bright red colour when the tool is looked at through dark glasses in the light of oxyacetylene flame.

Short sections of tight-fitting rubber hose can also be set flush with the striking ends of hammer-struck tools to keep chips from flying.

Dressing of Tools : Shock, cutting and pointed tools require regular maintenance of their edges or striking surfaces. Once the cutting or striking surfaces have been properly hardened and tempered, only an emery wheel, grindstone, file or oilstone need be used to keep the head in shape and the edges clean and sharp. Proper precautions should be taken before grinding hardened tools. They should not be ground until they have been drawn or tempered. Grinding should be done in easy stages with no attempt to take off much metal at one time. While grinding, the tool should be kept as cool as possible with water or other cooling medium. The manufacturer's recommendations for type and kind of grinding wheel should be followed. Each cutting edge should have the correct angle according to its use and be finished off with a file.

Redressing of Tools : Redressing or reshaping of tool edges or surfaces which are badly damaged is not recommended. It should be discarded.

Procedure for correct redressing of dull cutting edges is as under :

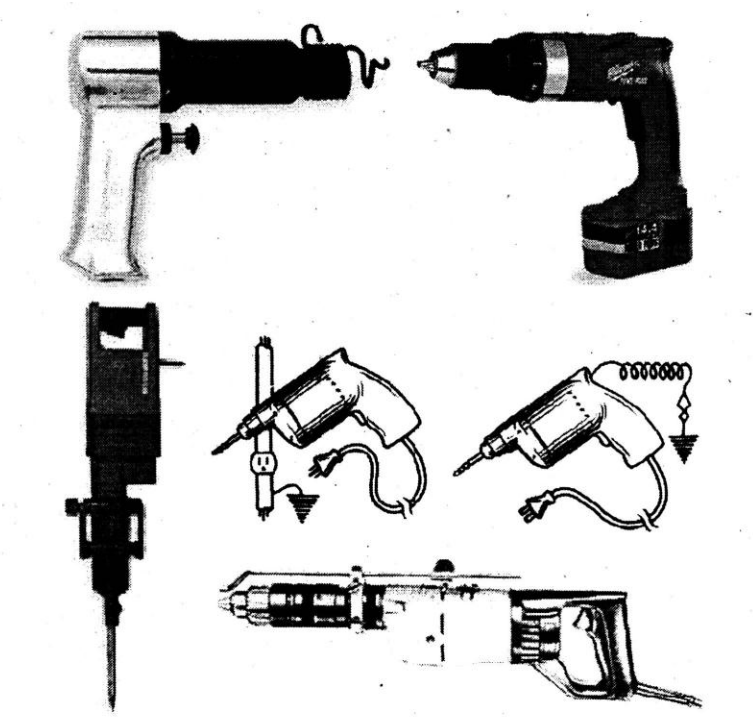
1. The tool edge should be supported firmly.
2. File or stone away from the cutting edge. Do not use a grinding wheel.
3. Restore the original contour of the cutting edge.

Handles : The handles of the tools should be of the best straight-grained material. Fitting of handles is very important. Poorly fitted handles make it difficult for the worker to control the tool. Design criteria for handle are its shape, diameter, length, angulations, texture and ergonomic aspects for convenience and safe use.

Handles should be fitted or replaced by an experienced person. Long use or shrinkage can loosen the handle. Wedges can be inserted in gap, tool head can be further driven in the handle with wedges reset and the protruding end of the handle cut off. If this is not possible a new similar handle, should be fitted after removing the old one.

4 PORTABLE POWER TOOLS

4.1 Types, Hazards and Safe Use :



Portable power tools are divided into five primary groups according to the power source : electric, pneumatic, hydraulic, gasoline and explosive (powder actuated). Several types of tools such as saws, sanders, drills, and grinders are common to the first three groups; whereas explosive tools are used exclusively for penetration work, compression and cutting. Pneumatic grinders, impact tools and flexible shafts tools are also in use. Hydraulic tools, are used mainly for compression work. .

A portable power tool presents similar hazards as a stationary machine of the same kind, in addition to the risks of handling. Typical injuries caused by portable power tools are burns, cuts and strains. Sources of injury include electric shock, flying particles in the eyes, fire, falls, explosion of gases and falling tools.

The power line should always be disconnected before accessories on a portable tool are changed, and guards should be replaced or put in correct adjustment before the tool is used again.

Care should be taken to set power driven tools in safe area where they may not be struck by passersby and activated. A tool should not be left in an overhead place where there is achance that the line, if pulled, will cause the tool to fall.

Flexible cords, cables or hoses should be hung overhead and on safe points, and not over nails, bolts, sharp edges, oil, hot surfaces and chemicals. They should be frequently checked for cracks/opened joints, cut phases or earth wires.

Electric Tools:

Electric shock is the chief hazard from electrically powered tools. Types of injuries are electric flesh burns, minor shock that may cause falls and shock resulting in death.

Main safety points for electric power tools are:

1. Flexible cable (cord) should be protected from misuse, abuse and damage to insulation resulting in broken or exposed live conductor.
2. Plug-socket connection should be tight and safe. No bare conductors should be inserted in plug. Three pin top should be used.
3. Metal casing should be effectively earthed. Earth .core of the flexible cable should be properly connected to the metalwork to be handled. Flexible conduit is not suitable for this purpose.
4. Second alternative is the use of 110 V supply with centre tapped to earth to reduce an effective shock voltage to 55-a relatively safe voltage.
5. Power cutting switches should be within reach and near the apparatus.
6. Regular maintenance to check earth core continuity and strength of earthing.
7. Additional back-up protection is ELCB. i.e. earth leakage circuit breaker which detects the current difference between power supply line and current returning to the supply point. In normal safe operating condition, this current difference is zero but if there is a fault and leakage starts to earth, a differential current occurs which operates the device that rapidly senses and trips its contacts to cut off power to the apparatus. See Part 6.2.3 of Chapter - II.
8. Electric tool should never be put in wet area or used in raining condition.
9. Double protection or double-insulated or all insulated type equipment which need not be earthed.
10. Dead man control. This tool operates till the button is pressed and it stops as the button is released. Portable saw, hoist and remote control pendant are of this type.

While using electric drills, saws and grinding wheels,' eye protection is always required. Drill bit should not be of excessive length, otherwise it may break. Electric saws should have guards. Circular saw (portable) should be equipped with a trigger switch that shuts off power when pressure is released. It will not run when not in use. Grinding wheel should be properly mounted and guarded.

Sanders should run away from the body as it cannot completely guarded. Dust should be cleaned daily by a low pressure (30 psi or less) air and wearing safety goggles. Vacuum cleaning equipment is safer.

Pneumatic or Air-powered tools are less hazardous than electric power tools. Grinders and impact tools have air hoses (pipes) which pose tripping or stumbling hazard. Self-storing recoiling air hoses are safe. Speed regulator or governor is necessary to avoid over-speeding the tool.

Impact tools include riveting guns and jackhammers. Air pressure safety valve, automatically closing valve actuated by a trigger located inside the handle (machine can run only when the trigger is depressed) and retaining device that holds the tool in place so that it cannot be fired accidentally from the barrel are necessary.

Air should be filtered and cooled moisture or water should be removed from the tool. Pneumatic tools are of two types - percussive and rotary. In rotary tool either piston and cylinder or rotor vanes are used. Speed regulator is necessary. Pneumatic tools are started and stopped by means of shut off valves and rotary valves. Rotary valves are equipped with a spring returning the rotary handle to its 'stop' position as soon as the handle is released. Maximum operating pressure is 6 bar. Additional handle is provided to control back twisting torque when the cutting tool (e.g. drill, reamer) gets jammed.

Effects of noise and vibration cause health hazards. Vibration and jerks cause strain in the joints and disease. 'White fingers' or 'Vasospastic vibration syndrome' is a disease due to vibration exposure and vascular spasm. 8 to 16 Hz frequency causes' the most harmful effects as it generates resonance in hand-arm system. Safe limit of vibration intensity i.e daily exposure is

60 HZ for 1 hour working and

112 HZ for 30 minutes working.

To reduce vibration, damping springs, air cushions and vibration absorbing handles are necessary.

Noise level near the tool should be measured and ear protection should be given to the operator if necessary. Eye protection is required due to flying chips. Two chippers should work away from each other, back to back, to prevent cuts from -flying chips. They should not point a pneumatic hammer at anyone. Neither should it be used to clean dust from clothes due to risk of intestine inflation. Jack hammer handles should have rubber grips to reduce effects of vibration and fatigue. Operators should wear metatarsal - type safety shoes to protect against fall of heavy hammer.

See Chapter-12 for Noise and Vibration.
See Part 3.4 of Chapter-24 also.

Hydraulic power tools are hydraulic chain saws and compression devices. A small leak can impose high oil pressure on finger. Therefore, proper pressure hose should be selected. Safety pins are provided to shear at pre-set pressure. Pins should be secured by retainers. Poor quality shear pins, improper design or use of sockets can cause sudden failure and result in flying missiles.

4.2 Selection, Inspection, Maintenance and Repairs :

Information and training to select right tool for the right job is necessary. If a small hole is to be drilled and if it is easily possible by a hand drill, power drill is not necessary. Manual hazards are less serious than the power hazards.

Tool supplier should be given complete information about the job for which a tool is required so that he can recommend the most appropriate tool for that job.

Normally portable power tools are to be used on light or home work. For continuous operation and production service or heavy work, 'industrial duty' tools are selected.

Periodic inspections are necessary to find defects and to keep the tool in good working condition. Then it serves the purpose of preventive maintenance. It prevents hazards and costly breakdowns. Defective tools should be tagged and repaired.

Record of date of inspection, fault noticed and date of repair is necessary. Cause of fault and detail of repair carried out can also be added to such record.

Workers should be trained to inspect tools, identify defects, report and repair. They should be warned not to do makeshift repairs and to do no repair work unless authorised.

For cleaning purpose non flammable and nontoxic solvent should be used.

Inspection Checklist

General : Low voltage equipment used in tanks and wet area? Tools well maintained? Motors in good condition? Approved tools used in explosive atmosphere? Tools left where they cannot fall?

Cords : Insulation, plugs and sockets unbroken? Cords protected against trucks & oil? Cords not in aisle?

Grounding : Ground wire fastener in safe condition? 3-wire plug extension cord? Defects or minor shocks reported?

Guarding: Guards used on grinders & saws? Movable guards operate freely? Eye & face protection worn?

4.3 Use of Personal Protective Equipment:

Gloves, loose clothing and jewellery should not be worn by workers using revolving tools such as drills, saws and grinders. The weight of most power tools makes it advisable for users to wear safety shoes (with steel toe) to reduce chances of injury, if the tool falls or drops.

While working at overhead places with power tools, the operator should wear a safety belt and use a good platform or support.

Dust type respirators should be worn on buffing, grinding or sanding jobs which produce harmful dusts.

Ear protection is necessary at high noise levels.

Safety goggles or face shields should be worn for work on grinders, buffing wheels and scratch brushes because the unusual positions in which the wheel operates will cause particles to be thrown off in all directions. For this reason, protective equipment is even more important than it is for work on stationary grinders.

Eye protection equipment (safety goggles or face shields) is a must in all operations where hardened metal tools are struck together, where wood working or other cutting tools are used, where anything is struck by a metal hand tool, or where the cutting action of a tool causes particles to fly. Clothing should be free of oil, solvents or frayed edges to minimise fire hazard from sparks.

EXERCISE

1. Explain, State, Mention or Discuss -

1. Causes and control of tool accidents.
2. Wrong methods to use hand tools.
3. Merits and demerits of centralised tool issue system.
4. Different types of hand tools and factors of their safe use.
5. Types of material handling tools and factors of their safe use.
6. Types of torsion tools and safe methods of their use.
7. Types of portable power tools and their safety aspects.
8. Safety aspects of using electric power tools.
9. Types of pneumatic power tools, their main hazards and control measures.
10. What type of PPE is required while working on which type of portable power tools?
11. Hazards and control of portable power tools.
12. Main causes and control of hand tools vis-avis. power tools.
13. Types of defects in hand tools.
14. How hand tools are misused? What are the methods of right use?
15. A safety programme for control of hand tool accidents.

2. Write Short Notes on

1. Ergonomic design of hand tools.
2. Criteria for careful purchase of hand tools.
3. Safe storage of hand tools.
4. Tool boxes.
5. Causes of tool failure.
6. Maintenance and repairs of hand tools.
7. Dressing of hand tools.
8. Handles of hand tools.
9. Metal cutting tools.
10. Wood cutting tools.
11. Correct and wrong use of screw-driver.
12. Non-sparking tools.
13. Knife accidents.
14. Safe methods to use portable power tools.
15. White finger disease.
16. Safe methods of using air-powered tools.
17. Noise and vibration control of pneumatic tools.
18. Hydraulic power tools.
19. Inspection checklist for portable power tools.
20. Double insulation.
21. Fail safe design of a portable power tool.
22. Main causes of hand tool injuries and remedial measures for them.
23. Safe practices to be followed in the use of hand tools OR power tools.
24. Spark resistant tools.

3. Explain the difference between

1. Centralised tool issue system and personal tool issue system.
2. Tempering of tools and safe - ending of tools.
3. Dressing and redressing of hand tools.
4. Metal cutting tools and wood cutting tools.
5. Chisel and File.
6. Hack saw and cutter.
7. Crowbar and shovel.
8. Pliers and pullers.
9. Double protection and Dead man control.
10. Shock tools and torsion tools.

4. Comment on the following explaining whether it is true or false

1. No work is finally possible without hand-held or hand operated tool.
2. It is wrong belief that non-sparking tools are safe.
3. Electric drill should not be used in wet condition.
4. Earthing of portable electric grinder is not necessary.
5. Trained purchase officer is necessary for ordering

Reference and Recommended Readings

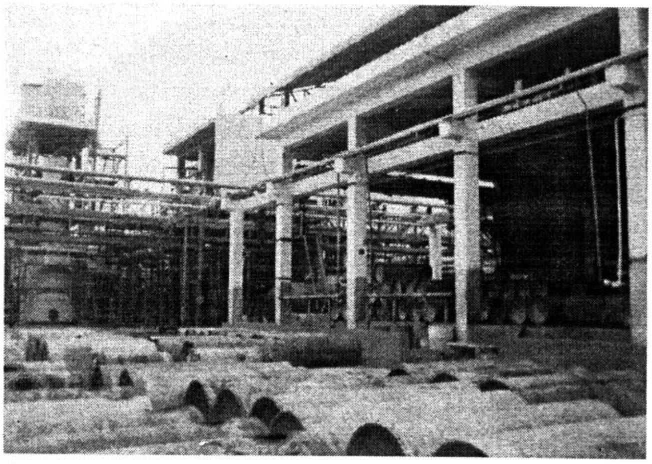
1. Accident Prevention Manual for Industrial Operations, NSC, USA.
2. Encyclopaedia of Occupational Health & Safety, ILO, Geneva.

CHAPTER – 18

Safety in Chemical Industry

THEME

1 INEVITABLE PLACE CHEMICAL INDUSTRY



The safest and simplest wav to avoid chemical Hazards and their ill-effects is to avoid chemical industry itself. But is it possible ? A place of chemical industry can be selected or shifted but it has to run somewhere on the earth and its place in our life has become inevitable because of the following reasons -

1. In homes we need cement, plaster, tiles, paint, plywood, glass, plastic, curtains, TV, tubes etc.
2. In kitchen we want gas, fuel, matches, heating appliances, metal or ceramic dishes etc.
3. For health we need drugs, pharmaceuticals, cosmetics, perfumes, talc etc.
4. Agriculture needs fertilisers and pesticides.
5. Construction requires minerals, metals, lime, cement, explosives etc.
6. Transportation needs petrol, diesel, gas, paints, rubber etc.
7. Clothing requires dyes, colours, soaps, detergents and a variety of chemicals.
8. In offices we want paper, ink, adhesives, photocopies, computer etc.
9. Basic needs like air, water, food, clothing and shelter are the product of chemistry.
10. Our human body itself is an astounding chemical industry carrying wonderful chemical processes within it.

All above materials are made from elements and their compounds and by direct chemical processes or indirect chemical treatment. Therefore, human life is becoming more and more dependent on chemicals making the place of chemical industry in society inevitable.

Chemical industry is also useful for national production and employment for many people.

It is, therefore, not possible to avoid or prevent chemical industry and the only way remains for us is to run this industry safely by identifying, avoiding and controlling its hazards. This, in turn, suggests the following ten-point safety programme :-

1. Study and identify chemical hazards using material safety data sheet (MSDS) and a system of classification, packaging and labelling should be developed.

2. Select safer technology.

3. Select safer siting of chemical industry for minimum loss to men, material, environment etc.

4. Design and construct the factory with all safety precautions from the very beginning.

5. Workplace hazards inside the factory should be controlled by good engineering controls, safe work methods or operating procedure and using personal protective equipment.

6. All requisite safety devices, fittings, instruments, equipment, machines etc., must be provided and well maintained.

7. Workers must be properly trained for safe operation of the plant and their role in emergency planning and control.

8. Safe transportation and handling of hazardous chemicals within and out-side factory premises.

9. Safe disposal of hazardous wastes within and outside factory premises.

10. Well monitoring and control of hazardous substances at work places and of occupational ill-effects and diseases by pre and periodical medical examinations of the workers.

2 NEED OF SAFETY IN CHEMICAL INDUSTRY

Though safety in each field is of equal importance, safety in chemical field needs more attention because of its specific nature. Chemical safety seems more complicated than civil, mechanical or electrical safety because each chemical has many properties, many processes, many hazards and many controls. The state, pressure, temperature, process parameters etc., are also changeable. Many hazard data and complete reaction documents are still not available. Many hazards are known after the accident only as in case of Bhopal and so many incidents. Engineering controls may not be possible or available at many places. Control devices and personal protections are inadequate many times. Warning devices may either not be available or not be functioning well. All these diversified working conditions and operational situations pose many dangers which need their proper knowledge and attention followed by proper safety measures and proper preventive as well as corrective maintenance.

Once upon a time textile factories were dominating in our country, but chemical factories, small and big, have been extensively increased. Process wise the highest number of factories in Gujarat are of chemical and chemical products. Table 5.16 of Chapter5 shows 501 (Total of NIC Group No. 30 & 31) out of total 21220 i.e. 2.36% chemical factories in the State in 2001. Employment wise it employed 24803 workers out of total 907101 i.e. 2.73% in the State. Table 5.21 states that accident wise also it is second (next to textile) contributing 1090 out of 12131 i.e. 8.98% accidents. The percentage of fatal accidents in chemical factories was 30.89% in 1997 in Gujarat.

Indian statistics of 1979 states that there were 9485 (Total of NIC Group No. 30 & 31) out 135173 i.e. 7.01% chemical factories and 609000 out of 6797000 i.e. 8.95% workers in these factories. As the latest all India statistics is not available, it is estimated that this percentage would have reached up to 10%. During 1992 there were 4141 out of 64631 i.e. 6.40% accidents in chemical factories which can also be estimated to rise up to 8% during last 6 years.

Thus it can be concluded that there are about 10% chemical factories in India, employing 10% of total manpower and contributing @10% of total accidents.

In Gujarat, considering subsequent growth of chemical factories, they are @21%, employing @21% of total manpower, contributing @9% of total accidents and@31% of fatal accidents.

Bhopal accident is remarkable. It caused more than 2500 deaths, many more injuries and became world famous attracting everybody's attention toward chemical safety. It has opened the eyes and shaken the governments and all safety people to wake up. Many expert committees have been formed and safety reports are published. The Factories Act is rapidly amended to include many matters on chemical safety. Many seminars have been held and the chemical wave is still continued. This shows the significance of chemical safety.

Before understanding safety aspects of a chemical industry, it is utmost necessary to study or refresh basic concepts of chemistry and chemical technology. For this purpose, please refer Chapter-32, Tables I to 4 before proceeding further.

3 TYPES OF CHEMICAL INDUSTRY

Before proceeding toward general safety aspects it is essential to have a look on variety of chemical industries and to realise a very wide scope of the subject. Thousands of volumes are available on chemicals, their processes, effects and control measures. But it is a fact that out of lacs of chemicals, published data of their dangerous properties is available for a few thousand only. Therefore most of the unknown chemicals must be handled very carefully. This requires basic knowledge of chemical safety. General knowledge is always useful for any type of chemical industry. The 27 dangerous operations, 29 hazardous industries and 29 notifiable occupational diseases due to such chemical industries are given in Parts 6.5 to 6.7 of Chapter-4.

National Industrial Classification (NIC-1987) Major Group No. 30 lists 50 types of chemicals and chemical products industries and Major Group No. 31 lists 35 types of rubber, plastic, petroleum and coal product industries. But this is still a broad classification and types of chemical factories are day by day increasing.

The chemical industries needing more attention are petroleum refineries, petroleum product industries and industries for basic heavy inorganic and organic chemicals, fertilisers (organic, inorganic or mixed), pesticides, dye-stuffs, paints, solvents, LPG, acids, alkalis and dangerous gas, toxic, flammable and reactive chemicals.

4 STATUTORY PROVISIONS

The Factories Act contains specific provisions on chemical safety. Section 2 (cb) defines 'hazardous process'. Section 7A and 7B specify general duties of occupiers and manufacturers for health and safety. Sections II to 20 regarding cleanliness, disposal of wastes and effluents, ventilation and temperature/dust and fume, overcrowding, lighting, drinking water, latrines, urinals and spittoons are all useful for chemical factories also. The whole chapter-IV (Sections 21 to 41) on safety is also relevant. Provisions of hoists and lifts, lifting machines, revolving machinery, pressure plant, floors, stairs and means of access, pits, sumps, openings in floors, excessive weights, protection of eyes, precautions against dangerous fumes, use of portable electric light, explosive or inflammable dust, gas etc., fire and building safety are also useful in chemical factories.

Chapter IV A (Sections 41 A to 41 H) regarding hazardous processes provides for site appraisal committees, disclosure of information, health and safety policy, medical examination (pre and post employment) of workers, health records, supervision, emergency standards, permissible limits of toxic exposure (Second Schedule), safety committee, duty to warn about and remove imminent danger.

Chapter V (Sections 42 to 50) on welfare provides for washing facilities, cloak room, first-aid, ambulance room, canteen, rest and lunch room, creche and welfare officer. Sections 87 to 91 A regarding dangerous operations, notice of accidents and diseases, inquiry, samples and health surveys are also useful. Section 87A prohibits employment on account of serious hazard. Section 96A for penalty for breach of section 41B, 41C or 41H is very severe. By section 104A burden of proof is shifted on a person who fails to fulfil the duty under this Act. Section IIIA creates worker's right to get information relating to their health and safety and to get trained for that. The Third Schedule lists 29 occupational diseases most of which are due to chemicals.

The Gujarat Factories Rules provide many rules under above sections of the Act. Rule 54, schedule IV for rubber mills, rule 61 for pressure plant, rule 63 for protection of eyes, rule 66 and 66A for fire safety, rule 102 and twenty six schedules there under (see Part 3 of Chapter 27), rule 103 and 104 for notice of accidents, poisoning and diseases are more important for chemical factories. Rule 61B for reaction vessels and kettles, rule 68C for polymerising and curing machines, rule 68D for thermic fluid heaters, rule 68E for fragile roofs, rule 68G for ovens and dryers, rule 68H for ship building, repairs and breaking and rule 68J for hazardous chemicals and processes suggest many safety measures.

Rules 68K to N, P & Q provide for disclosure of information to workers, CIF etc. and MSDS, rule 68R for health records, rule 68S for supervisors, rule 68T for medical examination, rule 68U for occupational health centime, rule 68V for ambulance van and rule 68W for decontamination facilities.

Amendment of 1995 (w.e.f. 15-2-95) in the Gujarat Factories Rules 1963, has added many details for chemical factories and for safety, health and welfare of the workers. Newly added following schedules, u/ r 102, must always be referred for strict compliance

Sch. 19	-	Chemical Works
Sch. 21	-	Solvent Extraction Plant
Sch. 22	-	CS_2 Plant
Sch. 25	-	Pottery, and
Sch. 26	-	Foundry.

See Chapter-23 for details of above mentioned provisions industry wise.

Other Laws on chemical safety include the Boilers Act 1923, Gujarat Boilers Rules 1966, Indian Boiler Regulations 1950, The Petroleum Act & Rules, The Explosive Act & Rules, The Insecticide Act & Rules, The Poisons Act & Rules, The Electricity Act & Rules, Gas Cylinder Rules 1981, Static and Mobile Pressure Vessels Rules 1981, Water and Air Pollution Control Acts and Rules, Environment (Protection) Act 1986 and Rules, Hazardous Waste Management Rules 1989, MSIHC Rules 1989, Chemical Accidents (EPPR) Rules 1996, Bio-Medical Waste Rules 1998, Building and Construction Workers Act 1996 and Central Rules 1998, Atomic Energy Act, Radiation Protection Rules etc. See Chapter-28 for all such Acts and Rules.

As the details of all above provisions are readily available in statute books, they are not reproduced here. It is recommended to refer them for details as they are directly applicable and create legal responsibility also.

5 INDIAN STANDARDS

Sectional lists of Indian Standards on chemical, Indian Standards on safety and BIS Handbook are readily available at Bureau of Indian Standards Offices. Each industry should select applicable INDIAN STANDARDS booklets from these sectional lists. They are most useful. A sample list is given below :

Code of Safety for Acetic acid 5208, acetic anhydride 5302, acetone 7445, air purifying canisters 8318, ammonia 4544, aniline 7415, benzene, toluene & xylene 4644, bromine 6953, calcium carbide 6819, carbon disulphide 5685, caustic soda 4264, laboratory safety 4209, 4906, glossary of terms, chemical and radiation hazards 4155, glossary of terms, respiratory protective devices 8347, glossary of terms, explosives 10081, chlorine 4263, classification of dangerous goods 1446, classification of hazardous chemicals and chemical products 4607, ethylene oxide 6269, cryogenic .liquids 5931, hydrochloric acid 6164, lead and its compounds 4312, LPG installation 6044 (Part I & II), mercury 7812, methanol 7444, nitric acid 4560, phenol 6270, phosgene 8185, sulphuric acid 4262, vinyl chloride monomer 9786.

Code of safety for Hydrochloric acid 6164, chlorosulphonic acid 6156, hydrofluoric acid 5184, aluminium chloride, anhydrous 9052, phosphoric acid 6818, caustic potash 6954, phthalic anhydride 7420, carbon tetrachloride 5311, nitrobenzene 8388, 9053, ethyl ether 13441, monochlorobenzene 9277, thionyl chloride 9744, aluminium alkyls 9785, hexane 10870, phosphorous trichloride 10920, acrylonitrile 11141, dinitrotoluene 12033, methyl bromide 12034, MEK 12141, trichloroethane 12142, tetrachloroethane 12143, asbestos 11451, hydrogen peroxide 14200, carcinogenic substances 14165.

Acetylene cylinders 8433, agitator equipment 9522, air pollution control - glossary 4167, limits 9005, methods of measurement of air pollution 5182 (Part I to 20), air pollution control in petroleum refineries 10179, gas cylinders 5845, 5903, 8451, colour code for gas cylinders 3933, for pipe lines 2379, electrical instruments for hazardous atmosphere 8945, (See Part 8 of Chapter-11 also), static electricity 7689, electro heat installations 9080, 9021, fluid flow meters 9115, venturi meters 4477, fire detectors 2189, 2175, fire extinguishers 2190, 5896 (See Part 2 & 3 of Chapter13 also), gas industry 7062, gas masks 8523, gas oven 7342, 4473, gas pressure pipes 8329, gas scrubber, cooler or absorber 9240, gases flammable classification 9570, gas detection 7577, 10386, gaseous emissions nitric acid 9005, sulphuric acid 8635, perchlorates of ammonium, potassium and sodium 13914, sulphur dioxide 13910, petroleum refineries 8636, process control valves 10187, manhole for chemical equipment 3133, measuring cylinders 878, solid mineral fuels 3810, testing atmospheric conditions 196, thermal insulating material 7240, 7413, thermocouple pyrometers 2053, vacuum-filters 6034, 5676, gauge 8276, pump 6849, technology 4110, 8245, valve-ball 9890 for LPG cylinders 8737, 8776, globe steel-10605, work environment monitoring code 9679, safety in microbiological laboratories 12035.

Guide for handling cases of pesticide poisoning 4015 (Part 1: First-aid measures. Part 2: Symptoms, diagnosis and treatment), packing 6604, code of safety for malathion 10872, zinc phosphide 9278, aluminium phosphide 9279.

LPG storage installations 6044 (Part I & 2), code of safety in electric and gas welding and cutting operations 818.

Unfired pressure vessels 2825, steel forging for fired and unfired pressure vessels 9683, glossary of terms relating to corrosion of metals 3531, cathodic protection of steel structures 8062 (Part I to 4), safety in compressed air 4138, steel plates for pressure vessels 2041, Non-destructive testing - magnetic particle 3415, 3703, 7743, 10724, 10543, radiography 2478, 2595, 2598, liquid penetrants 12889, concrete methods 13311, ultrasonic testing 2417, 9346, 11630, eddy current 12965.

Fire safety of buildings 3594, ventilation in petrochemical plants and refineries 12332, classification of flammable gases/vapours with air according to their maximum experimental safe gaps and minimum igniting currents 9570, maintenance and operation of petroleum storage tanks 9964 (Part I & 2), safety in electro-heat installations 9080 (Part I to 4), flash back arrestor (flame arrester) 11006, purchaser's data sheet for gas scrubber, cooler or absorber 9240, safety belt and harnesses 3521, breathing apparatus 10245 (Part I to 4).   .

Methods of sampling chemicals and chemical products 8883 (Part I & 2), methods of sampling and test for industrial effluents 2488 (Part I to 5), tolerance limits for industrial effluents CHD 12, or 2490 (Part I to 10), treatment and disposal of effluent? of cotton and synthetic textile industry 9508, liquid sedimentation methods for determination of particle size of powders 5282, solid.waste analysis 10158.

Plant layout, safe practice 8089, 8091, emergency showers and face mountains 10592, safety colours and signs 9457, accident prevention tags 8095, gas detector tubes 13293.

Code of Practice on Occupational Safety and Health Audit 14489.

OISD Standards:

Oil Industry Safety Directorate (OISD) has published the safety standards for oil refineries, LPG bottling plants, gas terminals, ONGC and GAIL installations etc. Some such standards are mentioned below:

OISD Standards:

OISD-106	Process design and operating philosophic on pressure relief and disposal system.
OISD-110	Recommended practices on static electricity
OISD-112	Safe handling of air-hydrocarbon mixture; and pyrophoric substances.
OISD-117	Fire protection facilities for petroleum depots and terminals.
OISD-118	Layouts for oil and gas installations.
OISD-119	Inspection of pumps. Inspection of compressors.
OISD-120	Inspection of turbines & diesel engines. Inspection of rotating equipment components.
OISD-121	Predictive maintenance practices. Inspection and maintenance of mechanical seals.
OISD-126	Specific maintenance practices for rotating equipment .
OISD-127	History recording of rotating equipment.
OISD-128	Inspection of unfired pressure vessels.
OISD-130	Inspection of pipes, -valves and fittings.
OISD-132	Inspection of pressure relieving devices.
OISD-137	Inspection of electrical equipment.
OISD-140	Inspection of jetty pipelines.
OISD-144	LPG bottling plant operations -
Vol. I	Design philosophies.
Vol. II	Operating practices
Vol. III	Inspection and maintenance practices
Vol. IV	Safety and fire protection
OISD-146	Preservation of idle electrical equipment.
OISD-147	Inspection and safe practices during electrical installations.
OISD-148	Inspection and safe practices during overhauling electrical equipment.
OISD-153	Maintenance & inspection of safety instrumentation in hydrocarbon industry.
OISD-154	Safety aspects in functional training.
OISD-156	Fire protection facilities for port oil terminals.
OISD-160	Protection of fittings mounted on existing LPG tank trucks.
OISD-161	Rescue and relief operation involving tank truck accident carrying LPG.
OISD-162	Safety in installation and maintenance of LPG cylinder manifold.
OISD-169	Small LPG bottling plants (Design and fire protection facilities).

See Chapters II, 13, 24 and 25 for relevant Indian Standards on the subjects of electricity, fire and explosion, industrial hygiene and health and personal protective equipment.

6 TYPES OF CHEMICAL HAZARDS AND CONTROLS

People working in chemical factories and dwelling nearby are exposed to various types of chemical hazards. Inflammable, explosive, toxic, corrosive, reactive, radio active, oxidising, reducing, decomposing, compatible and hidden hazardous nature of chemicals pose material or property hazards. In process, chemical and physical change, chemical reaction, pressure, temperature, level, flow, quantity and other parameters create process hazards. The vessels and equipment in which the chemicals are stored, handled or processed, pose vessel hazards. The inadequate,, defective, under-designed or wrongly modified control devices or failure thereof cause control hazards. Fire or explosion causes fire hazards. Effluent disposal and gaseous emissions bring pollution and toxic hazards. Leaks, spills and splashes cause handling hazards. Absence, non-use or failure of fire fighting equipment, personal protective equipment, emergency control devices reveal accident and emergency hazards. All other unsafe working conditions and unsafe actions pose a variety of hazards that all need to be prevented and controlled.

Many safety measures are available to deal with above hazards. Identification of contents, properties, hazards and quantity of chemicals, their content minimisation, proper storing, handling and packing; auto control, recording and warning devices for level, pressure, vacuum, temperature, flow, feed, speed, cooling, heating, stirring, discharge, contamination; remote control devices, proper ventilating, exhaust, scrubbing, neutralising, inactivating and incinerating devices; monitoring, measuring, recording, tripping, correcting and controlling system, fire fighting and personal protective equipment, emergency and disaster planning, controls and all engineering well designed process and plant layout and fully safe actions of workpeople are utmost necessary to fight these hazards and to control over them. Some types of hazards are as follows:

1 Health (Toxic) Hazards :

(a) Types of effects are -

Allergy, Irritation, Oxygen deficiency (asphyxiation). Systemic poisoning (eg damage to liver, kidney, CNS, reproductive system etc.). Cancer, Damage to unborne foetus (teratogenesis). Genetic effects on future generations (mutagenesis). Dust effect (pneumoniosis).

Some effects are acute (local or short term) and some are chronic (long term, delayed or after repeated exposures).

(b) Factors creating effects are -

Type of concentration of chemical. Combined effects of mixtures, Properties of the material including its toxicity. Work methods. Nature of exposure (short term, long term) Routes of entry (through nose, mouth or skin) and Individual susceptibility.

2 Fire and Explosion Hazards :

Heat generation due to chemical reaction, Open flame, Radiant heat. Friction, Spontaneous combustion. Electric current. Static electricity and Fuel or Solvents like Low flashpoint and Low boiling point liquids, Gases and Solids (dusts, powders, lumps, crystals)

3 Biological Hazards:

Biohazards refer to plants, insects, animal and human pathogens that pose a potential risk to the health of humans, animals and also to the environment. Their ill effect is the illness through infection or disruption of the environment. They can be unique to a specific occupation or may affect the general public as epidemic (e.g. cold virus) or spread from person to person like highly publicised AIDS.,

Occupational exposure is possible in bio-laboratory work, hospitals, nursing or medical research, farming, agriculture, slaughterhouses, meat cutting and packing etc.

Biological infections and parasitic diseases are caused by contact with domestic, laboratory and other animals. Occupations of such biohazards are : abattoirs, agriculture, animal attendants, bone and bone meal processing, butchers, dairy, forestry, hair, bristle processing, ivory horn processing, laboratory animals, hospitals, slaughter house, farms, gardens, chemical factories, meat packers, poultry, sewerage workers, stock farming, tanneries, veterinary work, wild life management, wood industry, transport and handling of animals etc. Disease-class wise worker groups are as under:

Bacterial Skin Infections	**Fungal Skin Infections**
Animal breeders Animal handlers Farmers Fishermen Food Processors Hide handlers	Bakers Bartenders Canny workers Cooks Dish-washers Domestic workers
Parasitic Skin Infections	**Viral Skin Infections**
Agriculture Grain handlers Harvesters Livestock workers Longshoremen Silo workers	Dairy workers Dentists Medical Practitioners Livestock handlers

Diseases caused by biological agents are : Anthrax Brucellosis, catarrh, erysipeloid, herpes virus infection infections, hepatitis, leishmaniasis, leptospirosis, lym-phocytic chorimeningitis, mice infection, Q fever, rabies (dog bite, hydrophobia), rat bite fever, ringworm, salmo-nellosis, toxoplasmosis, TB and asthma.

Biohazards can enter into body through inhalation, ingestion, injection or skin contact. The type and virulence of the organisms and the individual's body resistance can decide whether or not the person may contract the disease. If other chemical or physical hazards are combined in the environment, the combined effect can be enhanced. Thus other environmental stresses may cause additive or synergistic effect. Viral oncology (tumour) research can provide information on risk of cancer due to viruses.

Safety and Control Measures : These are necessary to prevent health effects of toxic, highly infectious or oncogenic bio-agents. A written control plan including instructions for awareness, emergency action, safe procedure for handling, first-aid and reporting is useful. Employees should be immunised by effective vaccine if available. Vaccination is effective against smallpox, tetanus, yellow fever, diphtheria and hepatitis B. Proper placement and medical surveillance are also important. Pre-placement medical examination can give a baseline reference. Work assignment records should be maintained.

Pregnant women working in oncogenic virus laboratories should be counselled at the earliest possible time. They should be transferred to a non-virological department if possible.

Good housekeeping, quick decontamination of place and equipment, sterilisation, cleaning by germicide, use of PPE, no eating, drinking, smoking etc. in work areas, display of biohazard symbol, animal care and handling, bio-safety cabinets (local exhaust ventilation), effective filtration of room-air, ultraviolet air locks and door barriers to separate areas of unequal bio-risks, change rooms, safety showers, effluent treatment etc., are important safety measures.

AIDS (Acquired Immune Deficiency Syndrome) caused by HIV (Human Immuno deficiency Virus) reduces body's ability to fight infections. Diagnosis of white blood cells (WBC), no sexual contact with AIDS partner, avoidance of intravenous drugs and. medical treatment are useful.

4. Atomic Radiation Hazards-

Radioactive substances and Radiation processes (X-ray, NDT, Nuclear power plant etc.) cause severe health hazards.

5. Preventive & Control Measures :

Six Basic Principles

1 Elimination of substance or process.
2 Substitution of safer alternative.
3 Distance, Guard, Enclosure, Isolation, Shielding or Segregation of hazardous process.
4 Ventilation, general & local exhaust.
5 Personal Protective Equipment.
6 Personal hygiene.

6. Emergency Control Procedures :

1. Speedy Leak & Spill Control procedures.
2. Emergency shut-down procedure.
3. On site emergency plan.
4. Off site emergency plan.
5. Mutual aid arrangement with neighbouring industries.
6. Retainership for help at the time of emergency.
7. Regular rehearsal of emergency procedures (drill), updating and reviewing of the plan.

7 MATERIAL (PROPERTY) HAZARDS AND CONTROL

Make a list of all raw materials, products, byproducts and intermediates. Identify them by their nature of hazard and risk potentials. Classify them as inflammable, explosive, toxic, corrosive, radioactive, reactive, oxidising, irritant, unstable, compressed gases, dust and others. Also note their hazardous properties viz. boiling point, flash point, LEL, UEL, LD, LC, TLV, MAC, IDLH, density, solubility etc., to understand the ill-effects of the chemical. Reference No. I to 4 given at the end of this chapter explain all such terms and give them for various chemicals. Reference No. II gives such hazardous properties of some selected chemicals.

The chemicals may cause either physical hazards or health hazards. The physical hazards are caused due to dust, corrosive, explosive, flammable and reactive chemicals, compressed gases and oxidisers. The health hazards are caused due to toxic, irritant and carcinogenic chemicals. Carcinogenic causes cancer. Mutagenic causes inherited changes and teratogenic causes harm to unborn. Micro-organisms and radioactive chemicals also cause health hazards' The hazards are also classified as first and second degree hazards. The first degree hazards are caused by corrosive, flammable, explosive, toxic and oxidising chemicals, heat or ignition source, human error and failure of equipment etc. The second degree hazards injure life and property and include fire, explosion, toxic exposure, corrosive chemicals, collision, slipping, falling etc.

7.1 Identification and Classification of Chemicals

Identification of chemicals begins with the knowledge of basic chemistry. Refer Table No. I in Chapter 32 to identify first some commonly used elements and radicals. This will help to identify the chemicals.

Chemicals are classified in different ways. For study (chemistry) point of view, they are broadly classified as inorganic and organic chemicals. Inorganic chemicals are sub-classified as metals and non-metals. Out of 104 elements, 80 are metals and majority of them (except mercury) are solids, shining, reflecting, good conductor and forming reducing agents and basic hydroxides. In non-metals, more than half are gases and remaining are hard solid, non-shining, less reflective, bad conductor and forming oxidising agent and acidic hydroxides. Some examples are given below:

Metals: Aluminium, Arsenic, Beryllium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Manganese,' Mercury, Nickel, Radium, Sodium, Tin, Uranium, Zinc etc.

Non-metals : Bromine, Chlorine, Fluorine, Iodine, Oxygen, Phosphorous, Sulphur etc.

Organic chemicals include carbon compounds. They are subclassified as under -

Aliphatic Compounds (without benzene-rings) : Hydrocarbons, Halogen derivatives of paraffin, Alcohol, Ethers, Aldehydes, Ketones, Carboxylic acids and their derivatives, organic compounds of Nitrogen and Sulphur,. Carbohydrates, Alicyclic compounds etc.

Aromatic Compounds (with benzene-rings) : Benzene and its derivatives. Aromatic amines, Diazo compounds. Dyes, Phenols, Aromatic alcohol. Aromatic aldehydes, Ketones and quinones and Aromatic carboxylic acids.

Heterocyclic Compounds and Polymers (with other-rings) : Furan, Pyrrole, Thiophene, Pyridine, Quinoline, Isoquinoline, Alkaloids-coniine, nicotine, Drugs, Hormones, Vitamins/Enzymes and Polymers Natural and Synthetic Rubber like neoprene, butadiene; synthetic fibres like nylon, orlon, vinyon, terylene, Synthetic plastics and resins like cellulose, formaldehyde, alkyd, vinyl, acrylate and polystyrene resins and silicones.

Chemicals are also classified as under :

1. **According to their Physical State** i.e. solid, liquid or gases. Fine particles of solid like powder, dust, fumes and smoke are called particulate matter. Their suspension in air or gas also exists. Liquids are classified as acid; alkali, solvent, suspension, liquid mixture, aerosols etc. Gases are classified as inert (N21 C02), reactive, toxic, irritant, corrosive etc.
2. **Noxious Gases :**
   (1) Irritant gases – Cl_2, NH_3, SO_2, NO_2, $COCL_2$, Aldehydes etc.
   (2) Systemic poisons – C_6H_6, CS_2, PH_3, Stibine, Mn, Nickel carbonyl, Arsine, Halogenated hydrocarbons etc.
   (3) Simple asphyxiants – N_2, CH_4, CO_2 etc.
   (4) Chemical asphyxiants - CO, H_2S, HCN etc.
3. **Dust (Particulate Matter):**

(1) Causing plenumoconioses - Coal, Silica, Asbestos etc.
(2) Causing Asthma - Cotton, Flour, TDI etc.
(3) Causing allergy - fungal spores, bird fanciers, lung, bagassation etc.
(4) Causing lung cancer - Chromium, Asbestos, Benzene etc.

4. Biological Agents and Diseases :

(1) Virus Rickettisia - Psittacosis, rabbis etc.
(2) Bacteria - Anthrax, Woolsorter's disease, Leptospirosis or Weal's disease, Brucellosis, Tetanus etc.
(3) Fungi - Ringworm, Moniliasis etc.
(4) Parasites - Hookworm
(5) Plant products - Dermatitis due to mango tree and cashew seed processing.

For details see the Schedule given under the Rules for manufacture, use, import, export and storage of hazardous micro-organism, genetically engineered organism or cells (Refer Part 10.9 of Chapter-28).

Some physical, chemical or biological agents cause skin diseases (dermatitis) and alcoholism, sickness or accident may also cause health effects.

The chemicals should be properly identified, classified and handled accordingly. Labelling on packages and containers is a basic requirement. For this purpose some major divisions are given below :

Corrosive Chemicals : Amyl trichlorosilane, Anisoyl chloride. Antimony pentachloride. Antimony pentafluoride, Benzoyl chloride. Benzyl bromide, Benzyl chloride. Benzyl chloroformate. Boron trichloride. Bromine, Bromine pentafluoride. Bromine trifluoride. Caustic potash. Caustic soda, Chloroacetyl chloride. Chlorine trifluoride, Chlorosulphonic acid, Chromic acid solution, Diethyl dichlorosilane. Ethyl chloroformate. Formic acid. Fluorine, Hexafluorophosphoric acid, Hydrazine, Hydrobromic acid. Hydrochloric acid. Hydrofluoric acid. Methyl chloroformate. Nitric acid. Perchloric acid, Oxybromide, Oxychloride, Tribromide, Trichloride of phosphorous, Tetrachloride, Sodium aluminats. Spent sulphuric acid, Sulphur chloride (mono and di). Sulphuric chloride, Thionyl chloride. Titanium tetrachloride. Phenol etc.

Oxidising Agent : Aluminium nitrate. Ammonium nitrate. Ammonium perchlorate. Ammonium permanganate. Barium chlorate. Barium nitrate. Barium perchlorate. Barium peroxide, Benzoyl peroxide. Nitrate peroxide. Permanganate of calcium. Chlorate and Magnesium chloride mixture. Chlorate of potash and soda. Chromic acid. Dimethyl hexane. Lead nitrate, Lithium peroxide, nitrate, perchlorate. Peroxide of magnesium. Potash permanganate. Permanganate of soda. Potassium bromate, nitrate, nitrite, perchlorate, permanganate and peroxide. Silver nitrate, chlorate, chlorite, permanganate, peroxide, and nitrite. Zinc ammonium nitrite. Zinc chlorate. Zinc permanganate, Zinc peroxide etc.

Carcinogens : Asbestos, Acrolein, Aniline, Acrylo-nitrile, Alpha- Naphthylamine, BetaNaphthylamine, Benzidine, Benzene, Benzyl chloride, Carbon tetrachloride. Chloroform, Chloropropane, Dioxin, Epichlorohydrin, Ethylene oxide, Formaldehyde, Perchloroethylene, Beta propiolacetone, Styrene, Tetrachloro ethane, Toluidine (ortho-meta), Toluenediamine, Trichloroethane, Trichloroethylene, Vinyl chloride, Pyridine, Phenol, 4-aminodiphenyl, Nnitrodiphenyl etc.

Poisonous Chemicals : Aldrin mixture. Aniline, Arsenate of lead. Arsenic acid. Bromide, Chloride, Sulphide of arsenic. Calcium arsenate. Phenol, Dinitrochlorobenzol, Cyanide of potassium and sodium, Cyanogen gas, Cyclohexane, Dinitrophenol, Ethyidichloroarsine, Hexaethyl tetraphosphate, Hydrocyanic acid and its fumes, Mercuric acetate, Marcuric ammonium chloride and benzoate, Mercuric cyanide, bromide, oxide. Iodide, Methyl bromide. Methyl dichloroarsine. Mustard gas. Nickel cyanide, Nitrobenzol, Nitrogen peroxide. Phosgene, Thio phosgene. Zinc arsenate, MIC (methyl iso-cyanate), Carbon monoxide. Cadmium, DDT, Methanoi, Phosphine and dangerous pesticides such as Parathion, Diazeomon, Tetraethyl pyrophosphate, Tetraethyl phosphate, Demeton, Scheadan, Methyl parathion, Cryolite, Pentachlorophenol. Dinitro-o-cresol, Endrin etc.

Pesticides - Insecticides:

Pesticides: Aluminium phosphide, aldrin, acephate, antu, Butachlor, Chlordane, Chlorpyrifos, Cycocel, Cypermethrin, DDT, Dimethoate, Decamethrin, DDVP, Dieldrin, Endosulfan, EDB, Formothion, Fenitrothion, Fenvalerate, Hexachlorobenzene (BHC), Heptachlor, Glyphosphate, Glyphosine, Malathion, Monocrotophos, Mercuric acetate, MEMC, 2,4-D Phosphomidone, parathion, Permethrin, Phenthoate, Phenyl Mercuric acetate, Quinalphos, Zinc phosphide etc.

Insecticides : Cupric sulfate, DDT, Leadarsenate, Liver of sulfur.

Fungicides : Bordeaux mixture, Chlornil, Chloropicrin, Cyprus oxide, Mercurous chloride, Pentachlorophenol.

Herbicides : Ammonium thiocynate NH,SCN
Vermicides: Anisole.

Explosive Chemicals : Amyl acetate. Carbon dust, Aluminium dust. Wood saw dust. Hydrogen, Sodium metal. Sodium nitrate. Potassium nitrate. Ammonium nitrate, Benzoyl chloride, Nitro glycerine. Phosphorous trichloride. Titanium powder, Hexane, Trinitro toluene, Carbon disulphide, Ethylene oxide. Cellulose films etc.

Solvents : Benzene, Acetone, Methanoi, Ethanol, Toluene, Carbon tetrachloride. Methyl chloride, Methylene chloride. Ethyl acetate. Ethyl ether. Methyl bromide, Nitro propane, Propyl acetate. Spirit, Petrol, Carbon disulphide. Ethyl benzene, Methyl-propyl, Turpentine, Chloroform, Aniline, Benzyl chloride, Bromobenzene, Chlorobenzene, Ethyl benzene, Ethylamine, Formic acid. Heptane, Glycerol, Iso Propyl acetate, Methoxy benzene (anisole), Methyloleat, Naphthalene, Nitrobenzene, Oleic acid. Phenol, Styrene, Vinyl acetate, Xylene, Ether etc.

Other Flammable Chemicals : Acetonitrile, Acrylonitrile, Aluminium triethyl, Amyl acetate, Amyl chloride, Amyl mercaptan, Amyl nitrate, Benzoyl peroxide. Butadiene, Calcium phosphide. Carbon disulphide. Carbon monoxide. Coal tar. Naphtha, Lacquer, Paint, Varnish, Diethyl aluminium chloride, Diethylamine, Dimethylamine, Ethyl aluminium dichloride. Ethyl chloride, Ethylene, Ethylene dichloride, Ethylene oxide. Ethyl nitrate. Ethyl nitrite, Heptane, Hexane, Iso octane. Liquefied Petroleum Gas (LPG), Lithium metal. Methane, Methyl acetone, Monoethylamine, Nickel carbonyl, Pentane, Petroleum naphtha. Phosphorous, Phosphorous anhydride, Photographic film. Sodium aluminium hydride. Sodium metal. Sodium methylate dry. Titanium metal powder, Vinyl chloride, Vmyl fluoride. X-ray film scrap etc.

Reactive Chemicals : Acetic acid. Acetone, Acetylene, Sodium, Potassium, Lithium, Magnesium, Calcium, Aluminium powder. Anhydrous ammonia, Ammonium nitrate. Aniline, Bromine, Chlorates, Chromic acid. Chromium trioxide. Chlorine, Fluorine, Hydrocarbons (Benzene, Butane, Propane, Turpentine etc.). Hydrocyanic acid. Hydrofluoric acid (HF), Hydrogen peroxide. Hydrogen sulfide. Iodine, Mercury, Nitric acid (Cone.), Oxalic acid. Peroxides, Phosphorous (white); Potassium chlorate. Potassium permanganate. Silver, Sodium, Sodium nitrite. Sodium peroxide. Sulphuric acid etc.

Alcohols : Allyl, ethyl, methyl, emyl, anisyl, benzyl, butyl, cetyl, citronellol, cyclohexanol, diols or glycols, lauryl, nerol etc.

Refrigerant Gases : Carbon dioxide CO, Ammonia NH, Freonetc.

Esters : Amyl acetate, arsenate, benzoate, borate, citrate, cynate, decanoate, glyceride, isocyanate, lipids, methacrylate, nitrite, oxalate, salicylate, stearate, succinate, sulfate, sulphonate, tertrate, thiocynate, thiosulphate, toluate, xanthates etc.

Ethers : Anisole (methyl phenyl ether), benzyl cellulose, thio ethers, RSR, vinyl ether etc.

Enzymes : Catalase, Deaminase, Dehydrogenase, Diastrate, Fermerit, hydrolases, lactose, oxidase, urease etc. Resins : Alkyd (glyptal), Allyl, Aminoplastic etc. Acids:

Inorganic : Hydrochloric, hydrobromic, hydrofluoric, hydroiodic, nitric, sulphuric, nitrous, sulphurous, sulphonic, chlorosulphonic, boracic or boric, phosphoric, phosphorous, perchloric, arachidic, arsenic, ascorbic, aspartic, aspirin, hydrazoic, behenic or docosanoic, bromic, chloric, chloroplatinic, chlorous, chromic, iodic, manganic, metaphosphoric, perboric, permanganate, persulphuric etc.

Organic : .Acetic, acrylic, adipic, amino or carboxylic, alginic, uric, uncleic, succinic, barbituric, benzenesulphonic, benzoic, capric or decanoic, hexanoic, caprylic or octanoic, carbolic or phenol, carbonic, carboxylic, caro's or persulphuric, ricinoleic, chloroacetic, cinnamic, citric, crotonic or butenoic, cyanic, cyanuric or tricyanic, ethylene di~minee tetraacetic acid (EDTA), fumaric, galic, gluconic, hexanoic, hydrodic, hydrobromic, hydrocyanic, hydrofluoric, hydrozy, hypoclorus, hypophosphorous, isophthalic, lactic, lauric, linolegic, meleic, malic, malonic, mandelic, methacrylic, molybdic, monobasic, necotinic, nucleic, octanoic, oleic, oleum, osmic, oxolic, oxydiacetic, oxydiethanoic, palmitic, pantothenic, pelargonic, phosphinic, phthalic, picric, pyrophosphoric, pyrosulphuric, pyruvic, racemic, ribonucleic, ricinoleic salicylic, sebacic, selenic, silicic, stannic, stearic, suberic, sulphanilic, fannic, tartaric, thiocyanic, thiosulphuric, tribasic, trihydroxybenzoic, uric, vanadic etc.

Compatible chemical means which can be stored or handled with that chemical to which it is compatible.

Incompatible chemical means which should not be stored or handled with that chemical to which it is incompatible. A list is given below :

Table 18.1 Examples of incompatible chemicals.

No.	Chemical	Incompatible Chemical
1	Ammonia (anhyd.)	Mercury, chlorine, calcium hypochlorite, iodine, bromine and hydrogen fluoride
2	Aniline	Nitric acid, hydrogen, peroxide
3	Bromine	Ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, turpentine, benzene and finely divided metals.
4	Chlorine	Ammonia, acetylene, butadiene, butane and other petroleum gases, hydrogen, Sodium carbide, turpentine, benzene and finely divided metals.
5	Copper	Acetylene, Hydrogen peroxide.

6	Hydrogen sulphide	Fuming Nitric acid, oxidising gases
7	Nitric acid (Conc.)	Acetic acid, acetone, alcohol, aniline, Chromic acid, Hydrocyanic acid, Hydrogen sulphide, flammable gases and nitratable substance.
8	Oxygen	Oils, grease, hydrogen, flammable liquids, solids or gases
9	Sulphuric acid	Chlorate, perchlorates, permanganates.

7.2 Material Safety Data Sheet (MSDS)

7.2.1 Format of MSDS :

For proper identification of material hazards a material safety data sheet should be prepared and supplied with each chemical so that its safety precautions .can be well understood. A specimen form is given below :

1. Chemical Identity:

1. Name of the Chemical
2. Formula
3. Synonyms
4. Trade name
5. Chemical Classification
6. Regulated identification
7. Shipping Name, Codes/Label
8. CAS No.
9. UN No.
10. ADR No.
11. Hazchem (EAC) No.
12. Hazardous Waste ID No.
13. Hazardous Ingredients and CAS No.

2. Physical & Chemical Data :

1. Appearance, State, Odour etc.
2. Specific gravity (Water = 1)
3. Vapour density (air = 1)
4. Boiling point
5. Melting/Freezing point
6. Vapour pressure
7. Solubility in water
8. Scrubbing/Neutralising/Inactivating media
9. pH
10. Others

3. Fire & Explosion Hazard Data :

1. Flash point
2. Autoignition Temperature
3. Flammable limits : LEL/.UEL
4. TDG Flammability
5. Explosion Sensitivity to Impact
6. Explosion Sensitivity to static electricity

7. Explosive material
8. Flammable material
9. Combustible and flammable Liquid
10. Pyrophoric material
11. Hazardous Combustion products
12. Hazardous Polymerisation
13. Corrosive material
14. Organic Peroxide
15. Oxidiser
16. Others

4. Reactivity Data:

1. Chemical stability
2. Incompatibility (Materials to avoid)
3. Reactivity
4. Hazardous reaction products

5. Health Hazard Data :

1. TLV (ACGIH)
2. STEL/SET
3. LC_{50} or LD_{50}
4. Odour threshold
5. Carcmogen ? Poison ? Liberates poisonous fume?
6. Routes of entry
7. Body parts that may be affected
8. Effects of exposure and symptoms
9. Emergency and first aid treatment
10. Engineering controls necessary for safe handling.
11. NFPA Hazard signals
12. Special Health hazards.

6. Preventive Measures:

1. Ventilation required and type
2. Personal protective equipment required and type
3. Handling and storage precautions

7. Emergency and First-aid Measure :

1. Steps to be taken in case material is released or spilled.
2. Waste disposal method for solid, liquid and gaseous waste.
3. Fire, extinguishing media, special procedures and Unusual hazards.
4. Exposure - First-aid measures. Antidotes, Dosages.

8. Additional Information / References

9. Manufacturer / Supplier's Data :

1. Name of Firm
2. Mailing address
3. Telephone/Telex/Fax Nos.
4. Telegraphic address
5. Contact person in emergency
6. Local bodies involved
7. Standard packing

8. Tremcard Details / Ref.
9. Other

10. Disclaimer:

7.2.1 Interpretation and use of MSDS

For the better understanding and use of the Material Safety Data Sheet, some terms are explained below:

1. Formula (Chemical) : It is a symbolic representation of a chemical entity or relationship between elements, molecule and atoms, e.g. H, one molecule of hydrogen, 2HSO two molecules of sulphuric acid, HO one molecule of water wherein there are two atoms of hydrogen and one atom of oxygen. CH benzene contains six atoms of carbons and six atoms of hydrogen in one molecule, group or ion. Thus by formula we can know the hazardous ingredient of a chemical.

2. Synonym : Indicates alternate name of a material. e.g. Dimethyl ketone or 2-Propanone for Acetone.

3. Trade Name : Commercial name of the product.

4. Chemical Classification : General classification is organic or inorganic. Hazardwise classification can be flammable, explosive, toxic or poisonous, corrosive, reactive, infectious, oxidising, radioactive etc.

5. CAS No. : It is Chemical Abstracts Service number to provide a single unique identifier with naming the chemical, e.g. CAS No. for acetic acid is 64-19-7. It does not indicate the hazards of a material.

6. UN No. : It is United Nations four digit number assigned to potentially hazardous material (e.g. Ammonia UN No. 1005) or Class of material (e.g. corrosive liquids UN No. 1760).

These numbers are internationally recognised and used by emergency response personnel (including ire fighters) to identify material during transport emergencies. UN, Hazchem, NA and PIN numbers have the same uses.

See also Part 14.2 (4).

7. Hazchem (EAC) - No. : Hazchem (hazardous chemical) Code or EAC (Emergency Action Code) is an emergency code confirmed by the Health & Safety Executive, UK. It consists of a number (I to 4) followed by one or two letters and signifies type of a fire extinguisher required, type of personal protective equipment required, whether the spillage should be contained or diluted with water, whether the material is reactive and whether evacuation of the surrounding area necessary. Hazchem No. of Sodium cyanide is 4X and that of Vinyl chloride is 2WE.

8. ADR No. : It is an Agreement concerning carriage of Dangerous goods by Road. This European agreement was arrived at Geneva by 19 European countries for the safety of international transport by road. It deals with the classification of hazardous substances, their packaging, loading and unloading, transportation and its equipment. It gives hazard identification numbers like UN hazard class number. Their comparison is given below.

Classification of Dangerous Goods by	
UN Number	**ADR Number**

1.	Explosives	2.	Emissions of gas due to pressure or due to chemical reaction.
2.	Gases-Compressed, liquefied, dissolved under pressure or deeply refrigerated.	3.	Flammability of liquids (vapours) and gases.
3.	Flammable liquids.	4.	Flammability of gases.
4.	Flammable solids.	5.	Oxidising (fire intensifying) effect.
5.	Oxidising substances or Organic Peroxides.	6.	Toxicity.
6.	Poisonous (Toxic) or Infectious substances.	8.	Corrosivity.
7.	Radioactive substances.	9.	Risk of spontaneous violent reaction.
8.	Corrosive substances.		
9.	Miscellaneous dangerous substances.		

Doubling (repeating) of an ADR digit indicates increase of that particular hazard. Prefix 'X' indicates that the substance can dangerously react with water. As an example ADR HIN (Hazard Identification No.) of Benzene is 33 (UN No. is 1114 and Hazchem No. is 3WE).

9. Appearance, State, Odour: Appearance includes colour. State means physical state - solid, liquid or gas. Odour indicates smell. Odour threshold is that minimum level (ppm) where the odour will start. If odour threshold is lower than the permissible safe limit (e.g. TLV, STEL, IDLH or LC), the odour indicates the presence of gas and some safety margin is available to run away or to take precautionary step. But if it is higher, the gas becomes toxic or hazardous before its odour starts and this condition is risky. In that event a reliable gas detector is useful. Sometimes odour is added to detect the gas leakage e.g. addition of mercaptan in domestic LPG. Ability to detect odour may vary from person to person and may mislead if the other odorous materials are simultaneously present.

10. Specific Gravity (water = 1) : It is the ratio of the density of a material to the density of water (which is I g/cc). Lighter material (Sp. gr. <l, e.g. benzene 0.88) will float and heavier material (Sp. gr. >l, e.g. sulphuric acid 1.84) will sink. This information is useful for spill or fire control.

11. Vapour Density (air = 1) : It is the vapour weight per unit volume. In MSDS it is given as the ratio of the density of a gas or vapour to the density of air. The air density is 1.293 gm/l, but here it is considered as 1 for easy comparison of gases. Lighter gases (Vd<l, e.g. ammonia 0.59) will go up (rise) in the air and heavier gases (Vd>l, e.g. chlorine 2.49) will come down on the bottom. This information is useful for ventilation design and evacuation (emergency) activity.

12. Boiling Point: It is that temperature at which the material changes from a liquid to a gas. Below this point the liquid can evaporate to form vapour but at the BP the change from liquid to vapour is faster. This increases the vapour concentration and its pressure. This condition poses higher risk of fire, explosion or toxicity.

13. Thermal Decomposition Products : If the material decomposes (breaks down) without boiling, the temperature at which it decomposes is given with the word "dec'. Some of the decomposition products are hazardous. The thermal decomposition products may be quite different from the chemicals formed by burning the same material (hazardous combustion products). Information regarding thermal decomposition is useful to design ventilation system where a material may be heated.

14. Hazardous Decomposition Products : They are formed when a material decomposes (without heating) because it is unstable or reacts with common material like water or air (oxygen). This information is useful to design storage and handling procedures. For example, phosgene decomposes into corrosive and toxic fumes of HCI and CO because of heating or coming into contact of water or steam. Here HCI and CO are hazardous decomposition products.

15. Hazardous Combustion Products : These are the chemicals which are formed when a material burns. They may be toxic, flammable, smoke, carbon particles or other hazards. Their amount varies according to temperature and oxygen (air) available. They may be different from the thermal decomposition products. This information is useful to decide the fire fighting material and procedure.

16. Melting Point : It is that temperature at which a solid material melts and becomes a liquid. This information is useful for storage and handling purpose. A melted material may distort a container.

17. Freezing Point : It is that temperature at which a liquid material freezes and becomes solid. This information is useful for storage and handling purpose. A frozen material may burst a container.

18. Vapour Pressure : It is .the pressure (mm of Hg) upon atmosphere of the vapour of a material at a fixed temperature (e.g. 20 °C). Higher vapour pressure indicates higher concentration and therefore higher hazard due to fire or inhalation.

19. Solubility : It is the ability of a material to dissolve in water or another liquid (solvent). It may be expressed as a ratio or described by words like insoluble, very soluble, sparingly soluble or miscible. This information is useful to decide a scrubbing media, spill control or fire fighting material and procedure. Such solvent should not be hazardous.

20. Scrubbing neutralising or inactivating media : These are those materials (liquids) which dissolve or react with the hazardous material (gas, liquid or solid) to diminish its hazardous exposure e.g. caustic, lime, water etc. If this is not possible, proper absorbent may be used e.g. sand, sponge rubber etc.

See Table 18.4 of this Chapter and Table-17 of Chapter-32 for scrubbers.

21. pH : It is a measure of the acidity or alkalinity (basicity) of a material when dissolved in water. It is expressed in a scale from 0 to 14 as under :

0-2	Strong acidic
0-5	Weak acidic
0-8	Neutral
9-11	Weak basic
12-14	Strong basic

This information is useful to select a neutralising material for scrubbing or effluent treatment or spill control.

22. Flash Point : It is the lowest temperature at which a material gives off enough vapour near its surface to form a flammable air vapour (gas) mixture so that it can be ignited if a spark is available. The lower flesh point indicates higher hazard as it can cause fire at a lower temperature. It is expressed as Closed Cup (CC) or Open Cup (OC). CC value is slightly less than the OC value.

23. Auto-ignition Temperature : It is the lowest temperature at which a material begins to burn in air without any contact of spark or flame. During heating if the material decomposes, the decomposed chemical may auto-ignite at some other temperature. Different test methods give different auto-ignition temperatures for the same material. Therefore this value is an estimate. The material should be stored, processed or handled well below its auto-ignition temperature to avoid the risk of self fire or explosion.

Substances liable to spontaneous combustion are those liable to spontaneous heating under normal conditions or to heating up on contact with air and being then liable to catch fire'.

24. Flammable or Explosive Limits (LEI/UEL) : The lowest concentration (percentage in air) of gas or vapour which will burn or explode if ignited, is called the Lower Explosive (or Flammable) Limit i.e. LEL or LFL. The upper concentration (percentage in air) of gas or vapour which will burn or explode if ignited, is called the Upper Explosive (or Flammable) Limit i.e. UEL or UFL. The range between LEL and UEL is called the Explosive (or Flammable) Range. The fire or explosion risk lies within this range but not out of it. Below LEL the gas-air mixture is too lean to ignite and above UEL it is too rich to ignite.

However the concentration above UEL should be considered dangerous as due to entrainment of fresh air, it may be diluted and enter the explosive range. Similarly after LEL if gas discharge is continued in the same air, it can also enter the explosive range. Thus explosive range can be reached depending on flow of gas and air affecting their concentration. Air and gas temperature may also affect Therefore the range should be considered as approximate values. For gas/vapour it is expressed in % of air (1% = 10,000 ppm) and for powder in gm/m3 of air.

This information is useful to avoid the conditions leading to the explosive range and to ascertain it before allowing any person to enter any vessel or confined space where such air-gas mixture is suspected. Explosimeters are available to detect this range. Detection should be of percentage of LEL and all safety devices (alarms, controls, trips etc.) should operate well below the LEL. Fire hazard should be prevented at predetermined percentage of LEL.

25. TDG Flammability : Transport of Dangerous Goods (TDG) classifies the materials according to their flammability as under

- 2.1 Flammable gas.
- 3 Flammable liquid (Subclasses 3.1, 3.2 and 3.3 based on flash point).
- 4.1 Flammable solid.
- 4.2 Spontaneously combustible material.
- 4.3 Material which gives off a flammable gas on contact with water.

26. Explosion Data (Sensitivity) : It gives explosive properties of a material e.g. low, moderate or high. It gives two types of sensitivity :

Explosion Sensitivity to Impact - It indicates whether or not the material will burn or explode on shock or friction, and

Explosion Sensitivity to Static Electricity - It indicates how readily the material can be ignited by an electric spark or static discharge.

27. Explosive Material : An explosive material is that material which can explode on impact or by electric spark. Schedule-1 of Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 defines 'Explosives' as those chemicals which explode under the effect of flame, heat or photo-chemical conditions or which are more sensitive to shocks or friction than dinitrobenzene (old definition) or pyrotechnic substance (firework) or which is capable of producing gas at such temperature, pressure and speed to cause damage to surroundings or exothermic reaction by heat, light, sound, gas, smoke or their combination (new definition).

28. Combustible and Flammable Material : Flammable solid, liquid or gas which can catch fire and burn rapidly or explosively are flammable materials.

The terms combustible and flammable both indicates the ability of a material to burn. Any material that will burn at any temperature is combustible by definition. Flammable are a special group of combustible materials that ignite easily and burn rapidly. For example, NaCI, CC_4 and CO_2 are non-combustible while sugar, cellulose and ammonia are combustible but non-flammable.

The more readily ignition occurs, the more flammable the material, less easily ignited materials are said to be combustible, but the line of demarcation is difficult to decide.

Normally combustible liquids are classified as those whose flash point is greater than 37.7°C (100 °F).

Flammable or Inflammable liquids are classified under MSIHC Rules as (1) Flammable gases (LEL upto 13% or explosive range 12%). (2) Extremely flammable liquids (FP<23 °C, BP<35 °C). (3) Very highly flammable liquids (FP<23 °C, BP>35 °C). (4) Highly flammable liquids (FP between 23 °C to 60 °C) and (5) Flammable liquids (FP between 60 °C to 90 °C).

Flammable liquids are extremely hazardous, as they give off vapours at low temperature and these vapours by travelling to a source of ignition can cause flash back to the flammable liquid. It is difficult to extinguish a burning flammable liquid with water because water may not be able to cool the liquid below its flash point.

Flammable gases (normally boiling point < 20 °C) are equally hazardous as flammable vapours as explained above. Confined flammable gases are most dangerous. Flammable gases are also defined as those which at 20°C and at standard pressure of 101.3 KPa, have LEL 13% or less or a flammable range of 12% or more regardless of the LEL.

Flammable solids can be ignited due to external heat, flame, process heating by interaction with water or other substances. Flammable solids are of various types (1) Dusts or fine powders e.g. cellulose, flour etc. (2) Spontaneously ignitable at low temperature e.g. yellow phosphorous (3) Those in which internal heat is built-up by microbial or other degradation activity e.g. fish meal, wet cellulosic material (4) Films, fibres and fabrics of low-ignition point materials.

Flammable solids are readily combustible or may cause or contribute to fire through friction or which are liable to undergo a strong exothermic reaction.

29. Corrosive Material : It can attack (corrode) metals or human tissues such as skin or eyes. Structure or metal container may become weak and eventually collapse or leak. Skin, eyes or other body parts can be badly affected (burning) by corrosive materials. Acids, halogen gases, chlorides, caustic, phenol etc. are corrosive.

30. Hazardous Polymerisation : A polymer is a natural or man-made material formed by combining units called monomers, into long chains, e.g. styrene is the monomer for polystyrene.

Polymerisation is the process of forming a polymer by combining monomers into long chains. Uncontrolled polymerisation can be hazardous, as it can cause heat, pressure or explosion. Some chemicals can polymerise on their own without warming, others upon contact with water, air or common chemicals. Vinyl chloride rapidly polymerises in presence of light, air or heat. Therefore polymerising conditions should be controlled properly, Inhibitors(negative catalysts or compounds that retard or stop an undesired chemical reaction such as polymerisation, oxidation, corrosion etc.) are normally added to products to reduce or eliminate the possibility of hazardous polymerisation.

31. Pyrophoric Material : Any liquid or solid that will ignite spontaneously in air at about 54.4 °C (130 °F). Titanium dichloride and phosphorous are examples of pyrophoric solids, tributylaluminium and related compounds are pyrophoric liquids. Sodium, butyllithium and lithium hydride are spontaneously flammable in moist air as they react exothermically with water. Such materials must be stored in inert gas or under kerosene. Some alloys (barium, misch metal) are called pyrophoric because they spark when slight friction is applied.

Pyrotechnic materials mean fireworks.

Catalysts of pyrophoric material which can burn in normal air, are replaced in the atmosphere of nitrogen blanketing. The workers have to wear self-breathing apparatus while doing such job, because in the atmosphere of about 90% nitrogen, oxygen is insufficient for breathing.

32. Oxidiser and Peroxide : It is a compound that spontaneously evolves oxygen either at room temperature or under slight heating. Oxidisers include peroxides, chlorates, perchlorates, nitrates and permanganates. These can react vigorously at ambient temperatures when stored near or in contact with reducing materials (that will remove oxygen or add hydrogen) such as cellulosic and other organic compounds. Storage areas should be well ventilated and kept as cool as possible.

Peroxides release atomic (nascent) oxygen readily. They pose fire hazards in contact with combustible materials, especially under high temperature conditions. They are used as oxidising agents, bleaching agents and initiators of polymerisation.

Oxidizing substances are not necessarily combustible in themselves but by giving oxygen they contribute to combustion of other materials.

Organic Peroxides contain bivalent 0-0 structure, are thermally unstable and may undergo exothermic self-accelerating decomposition.

33. Chemical Stability : A stable compound does not easily decompose or react readily. Chemical stability is the ability of a material to remain unchanged in the presence of heat, moisture or air. An unstable compound may decompose, polymerise, burner explode under normal environmental conditions. Special precautions are required to store or handle unstable materials. For examples, CS_2 decomposes in light and burns due to heat, spark, flame or friction and gives off toxic fumes of SOx. Caprolectum liberates NOx fumes due to heating. TNT explodes due to heavy shock or by heating. Thus conditions disturbing stability must be known.

34. Incompatibility : Compatibility means the ability of two or more materials to exist in close and permanent association indefinitely. Liquids and solids are compatible if the solid is soluble in the liquid. Water is compatible with alcohol (because it is miscible) but not with gasoline (e.g. petrol).

Incompatibility means disability to co-exist permanently. Therefore incompatible materials should not be stored or kept together. For example, toluene reacts violently with some acids, plastic or rubber, therefore, these substances should be kept away.

Incompatible materials can cause a fire, explosion, toxic release, violent reaction, polymerisation or destroy the structure or function of a product. This information is useful for storage and handling purposes.

35. Reactivity : Two or more chemicals can react with each other and give reaction products, e.g. $2H_2 + 0_2 = 2H_20$. A single chemical can react with air or water (which are also chemicals) and give the product, e.g. phosphorous burns in air and gives its oxides (P_2O_2 P_2O_5), sulphur burns and gives SO_2 etc.

Reactions are exothermic when they evolve heat and are endothermic when they need heat to maintain them. A reversible reaction is one in which the reaction product is unstable and goes back to the original substance spontaneously.

In MSDS we are concerned with the hazardous reaction or reactive material which can cause fire, explosion, toxic release or violent reaction with air, water or common chemicals or under environmental conditions. Phosphorous, CS, Sodium metal, acids (reactive with metals) etc. are known for their reactivity. This information is useful for storage, handling and process safety purposes.

36. Hazardous Reaction Products : These must be known for the safety of process, workers and environment. Here products are more important than the reaction because of their hazardous nature, e.g. Chlorine reacts with alcohol and forms explosive alkyl hypochlorite. If toxic fumes are to be generated, scrubbers are required, if flammable vapours are generated, inert gas blanketing is required and earthing of the vessel also becomes necessary. If reaction products are highly poisonous like NaCN, HCN etc., they are to be handled in a closed system.

37. Health Hazard Data : For TLV, STEL, IDLH, LD/LC etc. see Part 1.5.1, for routes of entry, see Part 1.5.3, for effects of exposure see Part 1.8.2, for engineering controls and Part 1.5.6 for health hazards, all of Chapter-24.

For emergency and first aid treatment and antidotes see Chapter-26, for fire and NFPA (National Fire Protection Association of USA) Code see Part 3.4 of Chapter-13, for ventilation see Chapter 10 and for personal protective equipment see Chapter-25.

TLV and STEL are given in 2nd Schedule of the Factories Act. LD_{50}, and LC_{50} are given in 1st Schedule of the MSIHC Rules for the purpose of major accident hazard. LD,, for insecticides are given in Rule 19 of the Insecticide Rules for labelling purpose. Lower these values, higher the toxicity. LD_{50} up to 200 mg/kg and LC_{50} up to 10 mg/l can cause major hazard. By local exhaust ventilation toxic gas, dust or vapour must be captured and effective PPE must be worn by the workers. Above STEL, SBA is desirable.

38. Tremcard : Transport Emergency Cards are to be given to the drivers carrying dangerous goods for emergency information which may be needed at any time during journey. The cards contain short information on nature of chemical, hazards involved, protective devices, emergency action for fire, spillage, leakage, first-aid etc.

See Part 6.2 of Chapter-28.

7.3 Safety Precautions, Supervision and Medical Examinations

A sample guideline is as under : The dangers of working with chemical substances can be reduced to a minimum by observing certain simple basic rules :

7.3.1 General Safety Precautions:

1. Gaseous, liquid or solid chemical substances whose properties are not fully known should be treated as dangerous and handled very carefully.
2. Avoid contact with chemical substances. Chemicals should always be handled mechanically or with protective equipment. Containers and implements which can be contaminated with chemicals should be handled wearing gloves. In special cases, additional protective measures will be utilised.

3. Cleanliness is a basic requirement for safe working with chemicals. Emission of dust, vapours and gases, and the spillage of liquids and solids can be largely eliminated by careful working. Local ventilation installations must be used. Implements should be cleaned immediately after use.
4. Chemical substances should always be used exactly according to the written procedure. Anyone deviating from the procedure on his own responsibility is a danger to himself and others.
5. Chemicals should only be used when the drums, sacks, containers or pipelines containing them are clearly labelled. Ensure that 'the product name and delivery number on the drums and on the delivery note coincide. Though appearance alone is no guarantee of correct identity, a visual check should be made. In case of doubt, or when a mixup has actually occurred, a report must be made immediately.
6. Many highly reactive chemicals may only be used under strictly controlled conditions. For substances which react violently with water, the water contact should be avoided.
7. Substances which decompose dangerously under the influence of air, elevated temperature, impact or pressure, or contact 'with catalysts, appropriate safety measures contained in the written procedure should be followed. Dry at low temperature. Release the vacuum in vacuum dryers with an inert gas instead of air. Do not open the drier before room temperature has been attained. Release the vacuum in vacuum distillations with an inert gas. Expose distillation residues to the air only when cold. Handle and store catalysts only under the specially defined conditions. Prevent compounds which are particularly prone to decomposition (e.g. certain diazo-compounds) from drying out (leaks, splashes).
8. Substances which ignite spontaneously e.g. white phosphorous, pyrophoric catalysts etc. should be handled under an inert gas or liquid. Where necessary wear special protective clothing. Keep the prescribed means of extinguishing on hand.
9. Prevent the possibility of dangerous combinations. Follow the written procedure precisely. When preparing work, ensure complete separation of compounds which are dangerous when mixed.
10. Not only actual explosives, but also numerous widely used chemicals can explode when exposed to catalysts, heat or impact. Examples : acetylene and derivatives, acetyl nitrate, acrylic acid and its esters, ethylene oxide, azides, azomethane, peroxides, chlorates, perchlorates, cyanogen chloride, hydrogen cyanide, hydrazine derivatives, ozonides, propargyl alcohol and other propargyl compounds, hydrogen azide etc. The handling of such compounds is governed by special safety measures, which are to be found in the written procedures.
11. Chemicals which are spilled or contaminated should not be simply discarded in the refuse bin, but disposed of according to instruction from the supervisor.
12. The quantities of chemicals stored in a chemical plant at any time should be kept to the minimum required for normal working.
13. Before starting any process, its raw materials, their properties (MSDS), chemical equation, its working temperature and pressure, flow or addition rate, type of vessel and its safety fittings, emergency controls, planning and procedure, evolution of any gas, complete reaction document, how it can go wrong and what could be its consequence, type of ventilation, electric fitting, personal protective equipment required, trips and alarms, safe close down procedure etc. must be known and studied.

7.3.2 Supervision by Qualified Supervisors

Under section 41C of the Factories Act, qualified supervisors are required to super-wise handling of hazardous substances. Rule 68-S of the Gujarat Factories Rules prescribes B.Sc or M.Sc with Chemistry or Diploma or Degree in Chemical Engg. with experience.

7.3.3 Medical Examinations and Health Records

Section 41B and C of the Factories Act, require medical examinations and health records of the workers engaged in hazardous processes. Rule 68-T of the Gujarat Factories Rules prescribed nre-employment and six monthly periodical medical examination. Form no. 32 for pre-employment and periodical examination and form no. 33 for fitness certificate are prescribed. Rule 102 states 27 schedules where at many places medical examinations of workers are prescribed. Looking to the hazards in chemical factories, such medical examinations are most necessary.

7.4 Information to workers and others :

Such information u/r 68K, GFR, requires :

1. Material Safety Data Sheet (MSDS) as per R68Q, in respect of every hazardous substance handled in the manufacture, transportation and storage in the factory. Their location and availability to the workers.
2. List of hazardous processes carried on in the factory.
3. Physical and health hazards arising from the exposure to or handling of substances.
4. Safety and control measures taken for above hazards.
5. Measures to be taken by the workers to ensure safe handling, storage and transportation of hazardous substances.
6. PPE to be used by the workers.
7. Meaning of labels and markings on the containers.
8. Signs and symptoms likely to be manifested on exposure to hazardous substances and to whom to report.
9. Measures to remove spillage or leakage of hazardous substances.
10. Role of the workers in the emergency plan and evacuation procedures.
11. Any other information necessary to ensure safety and health of workers.
12. Quantity of solid, liquid and gaseous wastes generated per day, their characteristics and methods of their treatment and disposal [S.41-B(3) &: R.68P].
13. On-site Emergency Plan and safety measures required to be taken [S.41-B(4)]. This requires a separate document.
14. Health Records should be made available to the workers [R.68R].

Such information shall be reviewed and revised by the occupiers to make them up-to-date [S.7A(3) & R.68M].

Above provisions create a need of SAFETY MANUAL so that such useful information for workers are properly documented and given to them for their daily use, emergency use and training. It is legally required to be furnished to the workers u/r 68K and to the Chief Inspector u/r 68L with any modification if necessary u/r 68M.

Thus Safety Manual becomes a basic (statutory) need for a hazardous factory.

Prepare your Manual to include all above information in details. Also include other information depending on the specific nature of your factory and necessary according to the expert's advice.

7.5 Hazard Communication System including Safety & Risk Phrases

Hazard communication system includes-

1. Qualitative description like health hazard, flammability hazard, reactivity hazard. Electrical hazard, machinery hazard, fall or slipping hazard elc.
2. Display of Hazard, Warning and Control indicating signs and posters as shown in figure 18.1. See Fig. 9.1 in Chapter-9 also.
3. Safe permissible limits of hazards like TLV, STEL, LD, LC, dBA etc.
4. Threshold quantities of hazardous chemicals as given in Manufacture, Storage and Important of Hazardous Chemicals Rules, 1989. (See part 10.8 of Chapter 28).

Fig. 18.1 Hazard, Warning and Control indicating Signs and Posters

5. CAS No., UN No., HAZ CHEM, DOT, SOLAS etc. (See Part 7.2.2 and Part 14.2-(4)).
6. Class label and Emergency Information Penal (See part 6.2 of Chapter 28).
7. TREM CARD (hazard information to be given to drivers of hazardous goods).
8. Index like DOW and MOND. (Energy hazard in facility)
9. Hazards prioritization by numbers as given by NFPA.
10. Safety and Risk Phrases.

Hazards prioritization given by NFPA is as under:

Health Hazards	H	= 0	Almost no health hazard
(based on TLV)		= l	Slight health hazard
		= 2	Moderate health hazard
		= 3	High health hazard
		= 4	Extreme health hazard
Flammability	F	= 0	Almost no flammability hazard
Hazard		= 1	Slight flammability hazard
(based on		= 2	Moderate flammability hazard
Flash Point)		= 3	High flammability hazard
		= 4	Extreme Flammability hazard
Reactivity Hazard	R	= 0	Almost no reactivity hazard
(based on Adiabatic		= 1	Slight reactivity hazard
Decomposition		= 2	Moderate reactivity hazard.
temperature)		= 3	High reactivity hazard.
		= 4	Extreme reactivity hazard.

Safety and Risk Phrases

Regulation 9 of the CHIP (Chemicals Hazards Information and Packaging) Regulation, 1993 gives requirements for the labeling of substances and preparations dangerous for supply. These include the name and address of the supplier, information about the substance, symbols and risk and safety phrases L 38 (Approved Guide to the Guidance and Labeling of Substances an(j Preparations Dangerous for Supply) gives guidelines particularly on: (1) the classification by physico-chemical properties, health effects and environmental effects; and (2) labeling by risk and safety phrases. These phrases are represented by number and .their specific meaning indicating type .of hazard in brief. Some phrases are represented by combined numbers.

Safety Phrases

S1	Keep locked up.
S1/2	Keep locked up and out of the reach of children.
S2	Keep out of the reach of children.
3/9/49	Keep only in original container in a cool, well-ventilated place.
S3/14	Keep in a cool place away from. (Incompatible materials to be specified by the manufacturer).
S 4	Keep away from living quarters.
S 5	Keep contents under ... (appropriate liquid to be specified by the manufacturer).
S 6	Keep under ... (inert gas to be specified by the manufacturer).

S 7	Keep container tightly closed.
S 7/8	Keep container tightly closed and dry.
S 7/9	Keep container tightly closed and in a well-ventilated place.
S 7/47	Keep container tightly closed and at a temperature not exceeding ... °C (to be specified by the manufacturer).
S 8	Keep container dry.
S 9	Keep container in a well-ventilated place.
S 10	--
S 11	--
S 12	Do not keep the container sealed.
S 13	Keep away from food, drink and animal feeding stuffs.
S 14	Keep away from ... (incompatible materials to be indicated by the manufacturer).
S 15	Keep away from heat.
S 16	Keep away from sources of ignition — No smoking.
S 17	Keep away from combustible material.
S 18	Handle and open container with care.
S 19	---
S 20	When using do not eat or drink.
S 20/21	When using do not eat, drink or smoke
S 21	When using do not smoke.
S 22	Do not breathe dust.
S 23	Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).
S 24	Avoid contact with the skin.
S 24/25	Avoid contact with skin and eyes.
S 25	Avoid contact with eyes.
S 26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 27	Take off immediately all contaminated clothing.
S 27/28	After contact with skin, take off immediately all contaminated clothing, and wash immediately with plenty of ... (to be specified by the manufacturer).
S 28	After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer).
S 29	Do not empty into drains.
S 29/35	Do not empty into drains; dispose of this material and its container in a safe way.
S 29/56	Do not empty into drains, dispose of this material and its container at hazardous or special waste collection point.
S 30	Never add water to this product.
S 31	---
S 32	---
S 33	Take precautionary measures against static discharges.
S 34	Avoid shock and friction.
S 35	This material and its container must b disposed of in a safe way.
S 36	Wear suitable protective clothing.
S 36/37	Wear suitable protective clothing and gloves
S 36/37/39	Wear suitable protective clothing, glove and eye/face protection.
S 36/39	Wear suitable protective clothing and eye face protection.
S 37	Wear suitable gloves.
S 37/39	Wear suitable gloves and eye/face protection.
S 38	In case of insufficient ventilation, wear suitable respiratory equipment.
S 39	Wear eye/face protection.

S 40 To clean the floor and all objects contaminated by this material, use ... (to be specified by the manufacturer).
S 41 In case of fire and/or explosion do not breathe fumes.
S 42 During fumigation/spraying wear suitable respiratory equipment (appropriate wording to specified by the manufacturer).
S 43 In case of fire, use ... (indicate in the space the precise type of fire-fighting equipment If water increases the risk, add 'Never use water').
S 44 If you feel unwell, seek medical advice (show label where possible).
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show tile label where possible).
S 46 If swallowed, seek medical advice immediately and show container or label.
S 47 Keep at temperature not exceeding ... °C (to be specified by the manufacturer).
S 47/49 Keep only in the original container at a temperature not exceeding ... °C (to be specified by the manufacturer).
S 48 Keep wet with ... (appropriate material to be specified by the manufacturer).
S 49 Keep only in the original container.
S 50 Do not mix with ... (to be specified by the manufacturer).
S 51 Use only in well-ventilated areas.
S 52 Not recommended for interior use on large surface areas.
S 53 Avoid exposure — obtain special instructions before use.
S 54 ---
S 55 ---
S 56 Dispose of this material and its container to hazardous or special waste collection point.
S57 Use appropriate container to avoid environmental contamination.
S58 ---
S59 Refer to manufacturer/supplier for information on recovery/ recycling.
S60 This material and its container must be disposed of as hazardous waste.
S61 Avoid release to the environment. Refer to special instructions/safety data sheets.
S 62 If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label.
S 63 In case of accident by inhalation: remove casualty to fresh air and keep at rest.
S 64 If swallowed, rinse mouth with water (only if the person is conscious).

Risk Phrases

R 1 Explosive when dry.
R 2 Risk of explosion by shock, friction, fire or other sources of ignition.
R 3 Extreme risk of explosion by shock, friction, fire or other sources of ignition.
R 4 Forms very sensitive explosive metallic compounds.
R 5 Heating may cause an explosion.
R 6 Explosive with or without contact with air.
R 7 May cause fire.
R 8 Contact with combustible material may cause fire.
R 9 Explosive when mixed with combustible material.
R 10 Flammable.
R 11 Highly flammable.
R 12 Extremely flammable.
R 13 Extremely flammable liquefied gas.
R 14 Reacts violently with water.
R 14/15 Reacts violently with water, liberating extremely flammable gases.
R 15 Contact with water liberates extremely flammable gases.
R 15/29 Contact with water liberates toxic, extremely flammable gas.

R 16	Explosive when mixed with oxidizing substances.
R 17	Spontaneously flammable in air.
R 18	In use, may form flammable/explosive vapour air-mixture.
R 19	May form explosive peroxides.
R 20	Harmful by inhalation.
R 20/21	Harmful by inhalation and in contact with skin.
R 20/21/22	Harmful by inhalation, in contact with skin and if swallowed.
R 20/22	Harmful by inhalation and if swallowed.
R 21	Harmful in contact with skin.
R 21/22	Harmful in contact ith skin and if swallowed.
R 22	Harmful if swallowed.
R 23	Toxic by inhalation.
R 23/24	Toxic by inhalation and in. contact with skin.
R 23/24/25	Toxic by inhalation, in contact with skin and if swallowed.
R 23/25	Toxic by inhalation and if swallowed.
R 24	Toxic in contact with skin.
R 24/25	Toxic in contact with skin and if swallowed.
R 25	Toxic if swallowed.
R 26	Very toxic by inhalation.
R 26/27	Very toxic by inhalation and in contact with skin.
R 26/27/28	Very toxic by inhalation, in contact with skin and if swallowed.
R 29	Contact with water liberates toxic gas.
R 30	Can become highly flammable in use.
R 31	Contact with acids liberates toxic gas.
R 32	Contact with acids liberates very toxic gas.
R 33	Danger of cumulative effects.
R 34	Causes burns.
R 35	Causes severe burns.
R 36	Irritating to eyes.
R 36/37	Irritating to eyes and respiratory system.
R 36/37/38	Irritating to eyes, respiratory system and skin.
R 36/38	Irritating to eyes and skin.
R 37	Irritating to respiratory system.
R 37/38	Irritating to respiratory system and skin.
R 38	Irritating to skin.
R 39	Danger of very serious irreversible effects.
R 39/23	Toxic: danger of very serious irreversible effects through inhalation.
R 39/23/24	Toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R39/23/24/25	Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.
R 39/23/25	Toxic: danger of very serious irreversible effects through inhalation and swallowed.
R 39/24	Toxic: danger of very serious irreversible effects in contact with skin.
R 39/24/25	Toxic: danger of very serious irreversible effects in contact with skin or swallowed.
R 39/25	Toxic: danger of very serious irreversible effects if swallowed.
R 39/26	Very toxic: danger of irreversible effects through inhalation.
R 39/26/27	Very toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R 39/26/27/28	Very toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

R 39/26/28	Very toxic: danger of very serious irreversible effects through inhalation and if swallowed.
R 39/27	Very toxic: danger of very serious irreversible effects in contact with skin.
R 39/27/28	Very toxic: danger of very serious irreversible effects in contact with skin and if swallowed.
R 39/28	Very toxic: danger of very serious irreversible effects if swallowed.
R 40	Limited evidence of a carcinogenic effect.
R 40/20	Harmful: possible risk of irreversible effects through inhalation.
R 40/20/21	Harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R 40/20/21/22	Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.
R 40/20/22	Harmful: possible risk of irreversible effects through inhalation and if swallowed.
R 40/21	Harmful: possible risk of irreversible effects in contact with skin.
R 40/21/22	Harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R 40/22	Harmful: possible risk of irreversible effects if swallowed.
R 41	Risk of serious damage to eyes.
R 42	May cause sensitization by
R 42/43	May cause sensitization by inhalation and skin contact.
R 43	May cause sensitization by skin contact.
R 44	Risk of explosion if heated under confinement.
R 45	May cause cancer.
R 46	May cause heritable genetic damage.
R 47	May cause birth defects
R 48/20/21/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and it swallowed.
R 48/20/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R 48/21	Harmful: danger of serious damage to health by prolonged exposure in contaci with skin.
R 48/21/22	Harmful: danger of serious damage to health by prolonged exposure in contad with skin and if swallowed.
R 48/22	Harmful: danger of serious damage to health by prolonged exposure if swallowed.
R 48./23	Toxic: danger of serious damage to health by prolonged exposure through inhalation.
R 48/23/24	Toxic: danger of serious datnage to health by prolonged exposure through inhalation and in contact with skin.
R48/23/24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R 48/23/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R 48/24	Toxic: danger of serious damage to health by prolonged exposure in contact with skin
R 48/24/25	Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R 48/25	Toxic: danger of serious damage to health by prolonged exposure if swallowed.
R 49	May cause cancer by inhalation.
R 50	Very toxic to aquatic organisms.
R 50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 51	Toxic to aquatic organisms.
R 51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 52	Harmful to aquatic organisms.
R 52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

R 53	May cause long-term adverse effects in the aquatic environment.
R 54	Toxic to flora.
R 55	Toxic to fauna.
R 56	Toxic to soil organisms.
R 57	Toxic to bees.
R 58	May cause long-term adverse effects in the environment.
R 59	Dangerous for the ozone layer.
R 60	May impair fertility.
R 61	May-cause harm to the unborn child.
R 62	Possible risk of impaired fertility.
R 63	Possible risk of harm to the unborn child.
R 64	May cause harm to breast-fed babies.
R 65	Harmful: may cause lung damage if swallowed.
R 66	Repeated exposure may cause skin dryness or cracking.
R 67	Vapours may cause drowsiness and dizziness.
R 68	Possible risks of irreversible effects.
R 68/20	Harmful: possible risk of irreversible effects through inhalation.
R 68/20/21	Harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R 68/20/21/22	Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.
R 68/20/22	Harmful: possible risk of irreversible effects through inhalation and if swallowed.
R 68/21	Harmful: possible risk of irreversible effects in contact with skin.
R 68/21/22	Harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R 68/22	Harmful: possible risk of irreversible effects if swallowed.

8 STORAGE HAZARDS AND CONTROLS

Mainly three types of vessels are used in industry. Storage vessels. Reaction vessels and Pressure vessels. Their safety aspect is discussed in brief below :

8.1 Material of Construction and Lining:

The first step toward controlling vessel hazards is the proper selection of construction of material for the vessel depending on the type of chemical to be stored or processed, chemistry of that chemical in relation to the material of vessel, type of use, durability required etc. Some information is given in Table 18.2 & 18.3.

Table 18.2 : Suitability of Materials

No.	Storage or Process	Suitable Material
1	Caustic Soda solution 50%	Monel (alloy of nickel and copper)
2	Brine (15% concentration)	-do-
3	Brine, saturated	Concrete tank
4	Chlorination of Benzene	Lead or glass
5	Polymerisation reactor to produce styrene butadiene rubber (SBR)	Stainless steel or glasslined vessel
6	Evaporator tubes for concentrating NaOH solution to 70%	Nickel
7	Caustic Soda (NaOH)	Steel, Nickel
8	Lining of rotary kiln in cement industry	High alumina and high mangesia

		bricks
9	Digestor of kraft paper mill	SS
10	Chlorine - Dry - Dry or wet	 Iron or steel, copper High silicon iron, silicon rubber, Kel-F and teflon
11	Urea autoclave	SS
12	Oleum	Steel tower
13	HCl - concentrated at 30°C	Teflon, Steel rubber lined PTEE and porcelin
14	HNO3 – aqueous -concentrated - concentrated at 100°C	SS Aluminium or Chroumium alloys (Cr> 18% for cold acid) High silicon iron, Kel-F
15	H_2SO_4 – to absorb SO_3 - pipes for 9% - pipe for dilute - upto 60°C	Packed steel tower lined with acid-proof bricks. Cast Iron Lead Lead lined vessel, Teflon, polythene
16	HCl absorber made of	Karbate
17	SO_3 absorber	Chemical stoneware
18	Ammonia - anyhdrous - liquid, shipment	 MS Steel container
19	Fruit juices, milk and milk products	Nickel
20	CCl_4	SS, tin, highs silicon iron (14% Si)
21	Alkaline solution	Nickel
22	Pressure vessel operating at 500 atm and 500°C	Mo9lybdenum SS
23	To pump caustic soda, chlorinated brine or hypochlorous acid	Rubber lined pumps
24	Rotary dryers	MS
25	Gobar gas plant - digester - gas holder	 Masonry wall MS
26	Coke oven - wall lining - regenerators	 Silica bricks Fire clay bricks
27	Fermentor to produce ethyl alcohol from molasses	Copper bearing steel
28	Reactor to produce PVC	Nickel or glass lined steel
29	Tubes for multiple effect evaporator for concentration of sugarcane juice.	Copper
30	Ceramic recuperators	Silicon carbide
31	Protection from rusting	G I Sheet
32	Fluorine, dry	Copper Vessel

Table 18.3 Non Suitability of Materials

No.	Storage or Process	Non Suitable Material

1	H2SO4 - 50 % concentration - 100% at 30°C	 Aluminium, MS, SS, tine, concrete Aluminium, tin, rubber
2	HCl 10% , Ferrous Sulphate, Aquaregia	Aluminium
3	HCl – concentrated	High Silicon cast iron (Si 14%)
4	WetSO_2	CI Vessel
5	H_2SO_4 – 95% or Ether	Silicon rubber
6	Fluorine, dry or wet	Glass
7	HCl, SO_2, Cl_2	Wood
8	Alkaline solutions	Centrifugal pump of pyrex or glass
9	HF aqueous at 100 °C	SS
10	Acetic Acid 40°C	Brass, Cl, MS, Tin
11	Atmospheric corrosion (slow oxidation)	Iron

Section 28 of Perry's Chemical engineer's Handbook (7th ed., 1997) is also useful for materials of construction.

8.2 Storage Vessels and their Safety Aspects:

Storage vessels are used to contain chemicals in bulk. Storage tanks to contain 10 tonnes to 10000 tonnes material arc constructed. Oil refineries, petrochemical plants or fertiliser plants have even bigger tanks also. If such tank leaks, breaks or caught in fire, a great hazard is possible. Bhopal tragedy was also arose from a storage tank of methyl isocyanate. When a fire, explosion or gas leak takes place from a bulk quantity, tremendous efforts are required to control the situation and save loss to people, property and environment. Therefore safety of storage tanks need; highest attention. Some main points are mentioned below -

The main types of storage are :

1. Liquid at atmospheric pressure and temperature (i.e. ambient condition).
2. Liquefied gas under pressure and atmosphere temperature.
3. Gas under pressure and
4. Refrigerated storage of liquids at low temperature (e.g. ammonia).

8.2.1 Safe Design and Maintenance :

After studying the properties of the material to be stored, proper selection of the material of construction, metal thickness, design, nozzles, connections, pipe lines, fittings, valves, pumps, lining, coating, jacketing, insulation, cladding etc. and colour coding are necessary. Table 18.4 gives some of such information:

Table 18.4 : Safety of Storage Tanks

No.	Chemical	Metal of the tank	Dyke / bund	Level gauge	Pressure & Temperature gauge	Safety Valve, Rupture Disc	Vent, Scrubber, Flare etc.	Transfer Pump
1	Sulphuric acid	MS	Yes	Float	No	No	Simple vent	Centrifugal

2	Hydrochloric acid	MSRL or FRP	``	``	``	``	Vent with water scrubber	``
3	Nitric acid 54% 98%	MS, Low carbon Aluminium	``	``	``	``	Simple vent	``
4	Alkali	MS	``	``	``	``	Simple vent	``
5	Oleum 23% 65%	MS	``	Dial meter	``	``	Vent in sulphuric acid tank	Submerisble or centrifugal
6	Formaldehyde 37%	MS	``	Float or Dial	Yes	Yes	Vent with water scrubber	Centrifugal
7	Ammonia (P 7 to 12 bar)	Steel (double wall for refrigerated storage)	``	Magnetic float, differential pressure, with alarm	``	Yes, double Safety Valve	Vent at height or water scrubber	Pressure
8	Chlorine (P 7 to 11 bar)	MS	``	``	Yes, double with high, low alarm	``	Vent with caustic or lime scrubber or flare	Dry air pressure
9	LPG (P 2 to 7 bar)	MS	``	``	Yes, double with high, low alarm	``	Vent with caustic or lime scrubber or flare	Dry air pressure
10	Flammable liquid / solvent	MS (SS for Methanol)	Yes	Close float or dial or DP	Yes if stored cold	Yes if inert blanketing	Vent with flame arrester or breather valve	Centrifugal

Outlet valve should be kept on side wall instead under the bottom to facilitate repairing and maintenance. Emergency bypass system should be kept ready.

To prevent escape of bulk storage remote operated isolation valve should be provided near outlet valve, drain point, filling point, pumps suction etc.

Non return valves (NRV) are useful to prevent reverse flow and excess flow valve (EFV) to prevent excess flow. If they are not fully reliable, shut off valves should be provided at critical service.

Tendency of purchasing second hand or old-repaired (fabricated with patchwork and welding) tank or vessel and to fit it to new requirement is an unsafe practice.

For corrosion prevention, tanks and pipelines should be coloured with anti-corrosive paints. Before painting, corroded portion should be tested and replaced. See Part 15.6 for details.

See Table 18.8 in Part 13.1(4) of this Chapter and Part 7.3.2 of Chapter-9 for colour coding of pipelines.

8.2.2 Notice of Identification :

A notice indicating the name of the chemical stored, tank capacity (tonnes or litres) and some important properties (e.g. Sp. gravity. Vapour density, Boiling point. Flesh point, LEL-UEL, TLV and Solubility) should be displayed on or near the tank. It should be clearly and easily visible and in the language understood by the workers.

8.2.3 Dyke or Bund :

This is required to restrict the spread of the leaking material, to safely contain within its periphery and to restrict the surface area of the leaking material in order to reduce its evaporation and for ease of fire fighting or other emergency control activity. The contained material can be safely disposed off or if it is burning, it can be extinguished easily by reaching up to dyke wall. If there is no dyke (or bund) the leaking material can come on the road or go in the plant and make more damage.

By partition walls in dyke, reactive chemicals or chemicals of different flash points can be kept segregated.

Dyke wall should be safe, sound and leak proof. Its floor should have a slope with a pit in corner to provide a discharge valve which should be opened only when the rain water or the stored (leaked) chemical is to be safely discharged. The volume of the dyke should be slightly more than the biggest tank inside. Wall height should be less than 2 mt (mostly 1 mt) for ease of fire fighting and maintenance work. Steps should be provided to go inside. Acid proof lining should be provided where required.

Dyke is always required if the liquid is stored at the atmospheric or low pressure and temperature. Refrigerated chemical when leaks, it remains liquid till it reaches its boiling point. Therefore dyke is required for it. e.g. refrigerated ammonia.

For highly volatile gases or gases at high pressure, dyke is not much useful and wire fencing is provided at a safe distance. For example, LPG, NGL, butane, butadiene, propane, ethane, methane, ethylene, ethylene oxide, hydrogen, acetaldehyde etc. are kept under vapour pressure where at the time of leakage, they spread rapidly and therefore their tanks are kept in open at a safe distance with fencing on four sides. The floor under such tank is given a slope so that dripping liquid may run away to avoid fire just underneath the tank.

While opening dyke discharge valve of a flammable material, spark should be avoided otherwise fire can travel inside the dyke and catch the tank.

Where possibility of explosion is there, impact or blast wall (thick, sound) should be provided near the tank.

8.2.4 Separation Distances :

Some recommendations are available to keep minimum safe distance, known as 'separation distance', between two tanks or between two groups of tanks or between a tank and a building or between a tank and a source of ignition. Based on radiant heat from the burning liquid or fire spread by vapour (VCE or BLEVE) such distances are prescribed. Normally a 15 m and 30 m distances are suggested. But based on the tank capacity this distance is variable. In a congested area, it is difficult to maintain such distance.

See Part 4.4 of Chapter-? for separation distances.

8.2.5 Vent Pipe :

While filling a tank air has to come out. A vent pipe at the top is required for this purpose. It is also useful to depressurise the vessel before opening it. Its diameter should be sufficient for easy escape of the air. Vent pipe may have a bend or roof to prevent outside thing (rain, bird etc.) going inside. Vent pipe should have wire mesh, flame arrester or breather valve if any flammable content is in the tank. They should be kept clean to avoid choking.

Normally flame arrester is suggested when the flash point of the content is below 23 °C. When explosive air mixture with vapour pressure is inside the tank, breather valve and flame arrester both are required. Flame arrester will disallow any spark to enter inside. The breather valve will inhale air when inside pressure will drop (due to vapour cooling) and exhale vapour when inside pressure will exceed the set pressure (due to pressure rising). Thus breather valve prevents continuous vapour discharge (evaporation) and loss of the content.

Vent with breather valve or safety valve is required when the boiling point of the content is below atmospheric temperature. When the content is flammable, nitrogen blanketing is necessary otherwise inhalation of the breather valve will take air inside which may form explosive air mixture. To avoid such situation, large diameter tank has a floating roof just floating on the surface of the liquid (flammable), thus disallowing any air gap.

Vent cooler (condenser cools the vent content and sends the liquid back to the vessel or receiver (e.g. methylene chloride).

Vent heater or pipe tracing (i.e. small diameter limpet steam pipe or coil is required to heat the content which can freeze on cooling (at ambient temperature) e.g. phthalic anhydride.

If the gas or vapour is toxic or corrosive, vent is connected with an appropriate scrubber, flare or incinerator.

If a flammable material is to be filled in a tank an inert gas (e.g. N,,) purging is required before filling the material and inert gas blanketing after filling the material.

Where there is a possibility of vent choking due to sublimation or polymerisation of the content inside, instead of vent pipe, safety valve or other device is necessary.

Where vacuum is required in the vessel, ventpipe is connected with a vacuum pump, ejector or a ventury system to provide suction. Such vapour being sucked is if toxic, it should be connected to a scrubber, if organic solvent, it should be connected with condenser and receiver and if flammable or/and toxic, it should be connected with flare or incinerator.

In transferring pressurised gases like chlorine, ammonia, LPG, open vent is not possible and it is connected as a return line in a closed circuit and the vent valve is closed after filling up the tank.

8.2.6 Overflow Pipe :

For the overfilling safety a safe overflow pipe is required. Its diameter should be slightly more than the inlet pipe diameter so that the overflow will be maintained if inlet flow is continued. If the diameter of the overflow pipe is smaller than that of the inlet pipe, continuing overflow may reach up to the top (may enter the vent) and damage the tank if the pressure is excessive. Connection of the overflow pipe should be 2 to 3 inch below the roof joint so that the material will come out (overflow) leaving some air space under the roof and the tank will never be subjected to the filling pressure. The overflow pipe should be extended unto bottom to disallow any free fall of the material and to discharge it in the dyke or any container safely.

If the liquid is fuming or contains less toxic or less flammable vapour it should have a valve or a bend with water sealing arrangement (if water is permissible) so that during normal condition vapour will not come out from the overflow pipe. The valve will be open only at the time of filling and closed when the filling is over. HCI vapour should be passed (scrubbed) in water and oleum vapour (SO) in sulphuric acid.

In process area, an overflow pipe of a measuring tank or day tank should be connected with a return line to the storage tank or some other container for safe discharge.

Tanks of pressurised gases or highly toxic or highly flammable material in bulk may not have overflow pipe. Instead, they will have high (safe) level alarm and feed pump trip device to stop the feed pump automatically at that level. Huge tanks (more than 1000 tonnes) have H (high) and HH (high-high) level alarms i.e. double alarms for double warning before reaching the highest level. Low level alarm is necessary where minimum level must be maintained. At that level the feed pump should automatically start.

The level alarm and feed-trip device (interlock) is a substitute of overflow pipe but if this device fails, an accident is possible. A simple overflow pipe is a safer engineering control. However the judgement depends on many other factors (e.g. type and quantity of material, storing parameters, flow, hazard, other safety, instrumentation and control etc.) and technical requirements.

8.2.7 Filling Ratio :

A tank should not be filled beyond its filling ratio (Rf) given as under -

$$C = \frac{D_{15} - Dr}{Dr\,(Tm-15)} \qquad Rf = \frac{95}{1 + C\,(Tm - Tf)}$$

Where
C = Coefficient of cubical expansion of liquid
D_{15} = Density of liquid at 15 °C
Dr = Density of liquid at Tm
Tm = Maximum bulk temperature °C
Tf = Filling temperature (mean) °C

Filling ratio or filling density is legally defined as the ratio of the weight of the material (liquid or gas) to the weight of the water that the tank will hold at 15 °C (See Part 3.5 of Chapter-28).

8.2.8 Level Indicator :

The quantity (measure) of the material in the tank should be externally visible so that its excessive (unsafe) filling can be avoided, minimum low level can be maintained and an order for next requirement can be placed.

An old manual method is to measure the level by a dip-rod (calibrated yardstick) inserting it from the top of the tank. This may be allowed for small or medium size tanks (upto 10 or 20 tonnes as in case of rail or road tankers). If the content is flammable, the rod should be non-metallic or it should pass through non-sparking lining of the hole (nozzle) to avoid spark while moving the rod. Dip rod system requires a worker to climb on the top of a tank and that is its disadvantage. But it gives correct measurement, not subjected to any instrumental error and that is its advantage. The Excise and Prohibition Department insists this dip-rod measurement probably due to this reason (they are more concerned with the excise duty i.e. money, connected with the quantity of a prohibited material).

From safety point of view, presence of a person on the top of a hazardous tank should be avoided. Now a days many types of level indicators are available. Simple glass tube (like water level gauges), float, magnetic, differential pressure, displacer, oscillator, electric, electronic and computerised control (from a control room) type direct reading level indicators are available in variety and they can be interlocked with other requirements also. They should be selected as per need depending on the type of content to be measured (e.g. sp. gravity, viscosity, colour, pressure, temperature, flow, fluctuations etc.) Like pressure and temperature indicator, reliability (quality) of a level indicator is equally important, otherwise it may lead to an error and accident. Therefore it should be ensured while purchasing.

8.2.9 Pressure Relief Devices :

If pressure inside a tank rises due to any reason, it may burst the tank from its weakest part or cause leakage from where it is possible. The content thus coming out is a material loss and in addition, it may create fire, explosion or toxic hazard. Therefore to avoid such situation a pressure relief device is necessary.

A safety valve is a common pressure relief device. It can be set to a predetermined (desired) pressure and when pressure exerted on it exceeds that pre-set value, it automatically opens and allows the pressure to release in the atmosphere or in a catch-pot or drowning tank if the content coming out is hot or hazardous. It automatically closes down also, after release of the excess pressure. Safety valves are of four types - spring loaded, weight lever, solenoid and pilot. Safety valves are used to release gas or vapour but not the liquid.

A Rupture Disc is required for the fast release or more flow from a bigger size hole or if internal pressure is too high or too rapid or the material is sticky and chokes the safety valve. This disc is selected based on many parameters (e.g. type of chemical, working pressure, temperature, reaction, material of the tank, viscosity, corrosivity, toxicity and flammability of the content etc.) One disc can be used for one pressure i.e. its set-pressure cannot be changed like safety valve, and after rupture the same disc cannot be reused. Once opened, it cannot reset at the lowered pressure like safety valve, and will allow the whole mass to come out till the hole is closed or the disc is replaced. This is its disadvantage. Therefore, it is inadvisable on tanks containing flammable gases or liquids. Rupture disc can be used in conjunction with a safety or relief valve. Then the disc will burst first without affecting the valve. If pressure is further built up, then the valve will open. Pressure gauge is provided between the disc and the valve to indicate that the disc has opened and what is the bursting pressure. Imperfections in manufacture, installation or caused by corrosion can result in premature failure of the disc. The rupture discs are used to release gas, vapour or liquid.

Relief valves do not full open at set pressure like safety valve, but open slightly and then open further as the pressure increases. They are of two types - spring loaded or power actuated by electric, air, steam or hydraulic power activated by a pressure sensor in upstream of the valve. Manually operated relief valves (like vent valve) are also possible but they are to be operated after seeing the pressure in the pressure gauge or after hearing an alarm. Relief valves are used for liquid discharge and not for gas or vapour.

Safety-relief valves can be used either as a safety valve or a relief valve, depending on the application. They are used for gas, vapour and liquids.

Fusible plug is a fitting filled with an alloy that melts at a predetermined temperature (not pressure) and gives way to the material to come out. Fusible plugs are used in boilers, domestic pressure cookers and compressed gas cylinders to prevent violent bursting. They are used for gas, vapour and liquids of high temperature.

Fire or Explosion Relief is provided by making the seam between the shell and the roof of the tank deliberately weak so that it may rupture first and the shell stays intact.

Vacuum breaker is also a type of pressure relief device and works like a spring loaded safety or relief valve but in the reversed direction. The outside atmospheric air pressure being higher than that inside the vessel, opens it to break the vacuum. This is required when the vacuum may increase to collapse the vessel. This device is used for air only.

Thus a relevant pressure relief device can be selected from above discussion. Double Safety Valves are required for bulk storage tanks of chlorine, ammonia, LPG, ethylene oxide etc., for the purpose of double safety. In that case there should be slight difference in their pressure settings so that functioning of both the valves can be verified by their one by one opening or no need arising to functioning by the second valve as the first opened safety valve works efficiently.

Where two or more safety valves are provided, their isolation valves are also provided to replace them while keeping at least one on the line. In such case, isolation valves on the line should be kept locked open' so that they cannot be closed unknowingly or without authority.

If addition is controlled, pressure can also be controlled. In nitration process addition of nitric acid should be at a slow or controlled rate, otherwise rapid pressure rise can burst the vessel. Safety valve may not be useful in that event. An efficient flow controller (automatic regulator) or an excess flow valve with a middle valve (for fine control) should be utilised in such condition, along with the pressure relief device.

It is better and safer to keep the pressure under control by controlling heat source, temperature or the rate of reaction.

8.2.10 Flameproof Fittings :

Electric fittings like motors, starters, switches, lamps, tubes etc., near the storage tanks containing flammable materials (see foregoing Part 7.2.1 for definition) should be of approved flameproof types and conforming to Indian Standards like 2148, 4691, 5571, 5780, 7693, 8239, 8240 etc.

Flameproof electric fitting is most essential if the material is having flash point less than 23 °C or if it is to be heated up to or above its boiling point, and also in case of solvent distillation. See Part 8 of Chapter II and Part 1.6 of Chapter 13. Other sources of ignition from welding, cutting, open flame, smoking, sparking, friction etc. should also be avoided.

8.2.11 Earthing & Bonding :

Tanks and piping containing flammable substance should have double earthings of appropriate type. Earthing pit should be recharged periodically for easy flow of the current. Resistance should be measured (below 10 K-ohm) and recorded. IS:3043 is useful for earthing code. Filling (inlet) pipe should be extended up to bottom or an inner limpet coil should be provided to avoid free fall and static charge due to material flow.

Pipe joints/flanges should have copper bonding to maintain electric continuity. Flange-guard is useful to divert the leakage downwards.

While loading or unloading flammable liquids or gases, the vehicle (road or rail tanker) should also be earthed during such operation.

8.2.12 Protective Media :

Low-boiling chemicals (e.g. Methyl bromide, ethylene oxide, ethylamine), toxic gases (e.g. chlorine, phosgene, HCN, NH,) or polymerising materials (e.g. MIC, styrene, acrylonitrile) should be kept below their boiling point/flash point. For this purpose either underground tank or insulation, or jacket and brine circulation, or refrigeration, or water showering etc. are employed. Brine and refrigerant gases are protective cooling media.

Chemicals of higher melting point (e.g. phthalic anhydride, dinitro benzene, naphthalene) are to be kept hot above their melting point for their easy- flow in liquid state. For this purpose steam jacket, limpet coil or tracings are used. Here steam is a protective heating medium.

Flammable chemicals or solvents of low boiling or flash points need inert gas blanketing (e.g. N , C0,,). For examples, acetaldehyde, acrylonitrile, benzene, EO, HS etc. need such inert gas blanketing to prevent spark contact and fire. When a safety or breather valve opens, first inert gas comes out and not the flammable vapour. Here inert gas is a protective medium.

Chemicals which catch fire in air (e.g. phosphorous, CS) are to be kept in water and chemicals which explode in water (e.g. sodium metal) are to be kept in kerosene and protected. Here water and kerosene are protective media.

Water curtains, sprinklers (spray nozzles) and remote operating valve are provided for chemicals like acetaldehyde, ammonia, HCN, where water can dissolve their vapour and keep the tank cool in case of fire. Water can also be used as a scrubbing medium for such water soluble gases.

Water sprinklers should work at a rate of 10 Lit/ m2/miri. Foam injection system (in atmospheric tanks) should work at a rate of 4.5 Lit/ 12/mn to extinguish the fire.

Thermal insulation (e.g. vermiculite cement of 2 inch thickness) for pressure storage and PUF insulation for refrigerated storage are also useful.

Thus selection and application of appropriate protective media for chemicals are always desired for safety of their storage or processes.

8.2.13 Personal Protective and Fire Fighting Equipment:

While working at storage, process, handling, use or transfer of chemicals, appropriate personal protective equipment (helmet, goggles, face shield, gloves, boots, apron, respirator etc.) should be worn by workers to protect themselves in case of any accidental discharge or exposure. Similarly a trained fire fighting team is also required to use appropriate fire fighting equipment. Training for use and maintenance of such equipment is most essential. See Chapters 25 and 13 for PPE and FFE.

8.2.14 Safe Loading / Unloading Procedure and Pump-transfer:

Liquid should be transferred by pump and not by any air pressure or truck-engine exhaust. Submersible pump at the top is more safe as it avoids the bottom valves and joints. Pressurised gases are transferred by their own pressure. Earthing of the tank, pump-motor and the truck-body are essential. Bonding on pipe-flanges are necessary. Flange-guards divert leakage downward.

8.2.15 Miscellaneous :

Storage safety is a wide subject and includes so many things. Despite above discussion a few things are to be mentioned. There should be minimum connections to a tank. Pipe joints should be safe and sound. Stiffeners and other supports should be properly provided. Staircase with handrail and working platform should be provided on the tank. For hazardous chemicals in bulk, the main outlet valve should be remotely controlled. Unloading bay should have ready connections with tank farm piping and fixed location for truck/tanker parking. Tanker carrying flammable material should have spark-arrester (muffler) over his exhaust pipe.

Dump vessel (one empty tank of the identical design to the storage tank) should be installed with ready connections to transfer the content in case of emergency. If possible, design should be to transfer by gravity.

Pump should be of proper design and capacity. Double mechanical seals should be provided to avoid gland leakage. Flange cap on flange-joint can divert the leakage downwards. Necessary drain and sample points should be provided.

In acids and alkali tank farm, acid proof lining/ flooring, water showers, cautionary notice, mechanical lifting device (e.g. trolley) and necessary PPE should be available. For spill control lime, sand, soda ash and ample water should be readily available.

Near tanks of toxic or flammable material, gas and flame detector with alarm, high pressure/temperature alarm, auto controllers, necessary scrubber or flare connections, FFE, PPE, good lighting and ventilation, safety showers, dyke, connections to ETP (Effluent Treatment Plant), emergency (alternate) power and water supply, emergency kit and tools, lightening conductor, wind sock, etc. should be provided as per requirement.

Modern sophisticated plants are run by latest control rooms where all process parameters are controlled and recorded from this control room. The latest instrumentation and computer control technology (e.g. DCS) is utilised.

See part 12 for instrumentation for safe plant operation.

8.3 Safe Storage and Handling of Flammable Liquids, Gases, Solids and Corrosive Chemicals

Storage tanks of dangerous chemicals must be constructed and controlled properly. Safe inventory must be maintained. Content should be minimum possible. Necessary safety fittings on the tanks should be provided. LPG tanks and tanks of other flammable or toxic chemicals must have proper safety devices. Toxic gases should be kept in liquefied state if possible. Cooling media and device, safety valves, pressure gauges, temperature-gauge, scrubber, level or content indicator, flare, water curtain, toxic exposure sensors and alarms, emergency bypass, safe discharge and collection, etc. should be provided as per requirement. Name and quantity must be clearly mentioned to assess the hazard potential. Barrels, carboys, glass vessels must be kept, handled and used in safe manners. Use emergency kits, tools etc. where necessary. All the vents of storage ranks of low boiling chemicals should be connected to an appropriate condenser or scrubber, Alternate power (e.g. 1x3 set) must be kept ready to run the cooling system, scrubber etc., in case the main power fails.

Safety measures of some specific chemicals arc stated below

8.3.1 Handling of Flammable Liquids

General guidelines for loading/unloading liquids

1. Take care of adverse weather conditions.
2. Safe access to the top of the trailer tank car.
3. Suitable fire extinguishers.
4. Where air pressure is needed or other gases such as nitrogen, adequate hose lines should be provided with reducing valves. Pressure should be as minimum as possible. Soundness of the pipe line and joints should be checked. Breakable pipes should not be used for toxic chemical.
5. Steam lines, if heating is necessary.
6. Personnel discharging duty should be in the vicinity.
7. Adequate personal protective equipment should be provided.
8. Emergency shower and eye washer should be provided.
9. Ensure that sufficient space is available in the receiving tank.
10. Training of personnel necessary.
11. Avoid mixing of chemicals. Take full precautions. .
12. Routine thorough check-up procedures.
13. Proper identification on discharge lines.
14. Earthing for transferring flammable liquids. Muffler on exhaust pipe.
15. Truck/tanker should be fixed by brakes or wheel-blocks and engine stopped while loading or unloading.

Flammable liquids are easily ignited and difficult to extinguish. Their vapours form explosive mixtures with air. Flammable liquids in unopened containers offer only moderate fire risk. They however, become severe fire hazard when containers are open or leaky. Before handling, containers should be carefully inspected and damaged or leaky containers, if any, be segregated. Containers should not be dropped, rolled or so handled as to risk damage to them.

Good housekeeping standards are-essential in storage areas. Such areas should be isolated by distance or constructions so that they do not expose important buildings to fire and in turn are protected from fire originating elsewhere. The extent of isolation depends upon the factors such as the maximum quantity of flammable liquid may be stored, the severity of the fire hazard presented by the flammable liquid etc. Detached locations should be preferred. Best locations are in the open under non-combustible weather canopies with minimum wall enclosure or in one story buildings without basements. Where storage in detached locations is not possible and the use of main building is unavoidable, with liquids offering only fire hazard, a room cut off from the rest of the space by fire resistant walls may be used. Where both fire and explosion hazard may exist in a main building, storage room should be located at an outside wall , cut off from other spaces horizontally and vertically with fire and pressure resisting construction. Floors should be liquid tight with slight down gradient to permit drainage. Rooms to bewell ventilated to safe guard against fire and explosion hazards as also against health hazards. Provision should be made for automatic sprinkler protection and all potential sources of ignition should be eliminated. Cutting and welding operation and smoking should be prohibited in storage area. The limitation regarding the maximum number of drums that may be stored in a particular location, the height of piles etc. would along other thing depends upon the severity of fire hazard associated with a particular flammable liquid.

8.3.2 Handling of Flammable Gases

Gases are generally contained in cylinders, in the compressed liquefied or dissolved state. Flammable gases will pose fire hazard when they leak or escape from their containers. Also when a gas is subjected to a high pressure, it could burst the container with serious consequences. In handling and storage it must be ensured that the cylinders are protected from damage or deterioration and heat. Some of the precautions to be taken are outlined below.

Cylinders should 'not be dropped, dragged, rolled on their side or permitted to strike one another or other surface violently. When removable caps are provided for valve protection, such caps should be in place at all times expect when cylinders are in use. It is safer to use suitable trucks to move them even through short distances. They must not be, lifted by their cap or with the aid of rope or chain slings. A safe cradle on platform with guard rails should be used for the purpose. Cylinders should not be used as rollers, or supports for any purpose other than to contain the contents as received.

Storage room for the cylinders should be dry, cool and well ventilated. Where practical, they should be of fire resistant construction. Highly flammable solvents, combustion waste materials, corrosives and cylinders of oxygen should not be stored near cylinders containing flammable gases. In outdoor locations they should be kept off the ground on a raised concrete pad or non-combustible rack and sheltered from sun by means of non- combustible canopy.

See also Part 8.6 following.

8.3.3 Handling of Flammable Solids

A large variety of solid materials used in industries and at other places present fire risk. Flammable solid materials become particularly hazardous under certain conditions. Some possess the ability of being easily ignited by external sources such as sparks and flame. Some other are liable to heat spontaneously and ignite. Certain materials have the property of releasing flammable gases when in contact with water. In the handling and storage of various flammable solids apart from taking normal precautions, additional precautions will have to be taken to guard against the hazard posed due to condition or circumstances under which flammable materials may became severe fire risk.

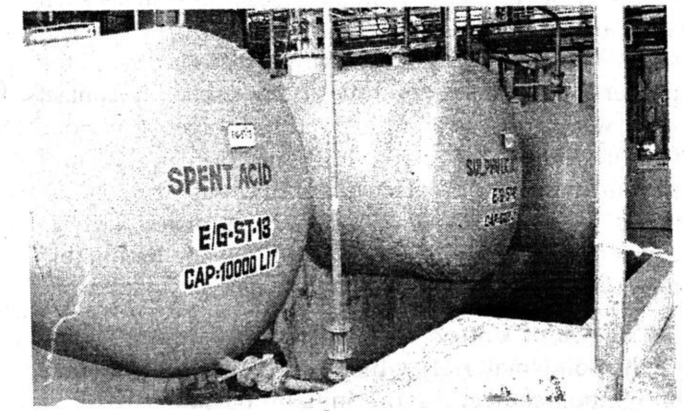
Bales of Cotton and Jute hemp represent some of the solid materials which are easily ignited. With an ignition source, the fire initially flashes over fibres on the surface and then -travels at a slower rate between bales and into individual bales. Ignition source may be electricity, mechanical sparks, smoking, matches etc. Bales should be protected from such source. Electrical wiring in a warehouse for the bales should be installed in a rigid metal conduit for protection against mechanical damage. Spark producing electrical equipment including switches, fuses, circuit breakers should be in dust tight enclosures. Ware-house to be of non combustible construction with floors sloping to prevent accumulation of water. Piles sizes to be not too large and about 3m wide aisles space to be maintained between piles. With bales of jute, at least 1m wide space should be left along the walls and with bales of other fibres, at least 0.8m wide gap is to be left. The height of the pile should be limited taking into account the floor loading capacity and the weight of bales when soaked with water. In any case at least 1m head clearance is to be maintained between the top of the piles and the deflectors or sprinklers.

See Part 9 of Chapter-21 also.

Bituminous coal represents flammable solids liable to spontaneous combustion. It absorbs oxygen from the air and the absorption is more rapid when the coal if freshly mined or contains much fine dust. Moisture adds oxidation. Coal should not be stored in contact with sources of external heat or over trenches, manhole covers and similar surfaces which may allow movement of air through piles. In yards, piles height to be limited to 3m with low grade coal and 5m with best grade coal. Where bins are used for storage, these should be of non-combustible material with the structure roofed over to protect the coal from rain. The space above the coal should have adequate ventilation to prevent concentration of gases given off by the coal.

Calcium carbide and Alkali metals are some of the solids which when in contact with water liberate flammable gases. In some cases the gases released may be ignited from the heat of reaction. These materials are to be packed in air tight containers and stored in dry cool and well ventilated building of non-combustible or fire resistant construction. They should be separated from combustibles, oxidising agents and mineral acids.

8.3.4 Handling of Corrosive Chemicals



Corrosive chemical will cause severe damage when in contact with living tissue or, in case of leakage, ill materially damage or even destroy the surrounding they come in contact with. It is likely to cause a fire when in contact with organic matter or certain chemicals. Certain corrosive substances have other more serious hazardous properties (toxicity, flammability etc.) and are commonly classed as toxic or flammable etc. rather then as corrosive.

Important corrosive substances are : Acids and anhydrous alkalis, halogens and halogen salts, organic halides, organic acid halides, esters and salts.

When in contact with human tissues, most corrosive substances will produce chemical burns, while certain other substances (as Chromic acid) produce deep ulceration. Many corrosive substances have a defeating action on the skin and may cause dermatitis.

The safeguards against these hazards are :

1. Preventing or minimising contact between corrosive substances and skin, mucous membranes and eyes.

2. Corrosive substances should not be allowed to come in contact with materials that may react.

3. All the containers, pipes, apparatus, installations and structures used for the manufacture, storage, transport or use of these substances may be protected by suitable coatings, impervious to and unaffected by corrosives.

4. All containers or receptacles should be clearly labelled to indicate their contents and should bear the danger symbol for corrosives.

5. A high standard of maintenance and good housekeeping is essential.

6. Adequate ventilation and exhaust arrangement whether general or local, should be provided whenever corrosive toxic gases or dust are present.

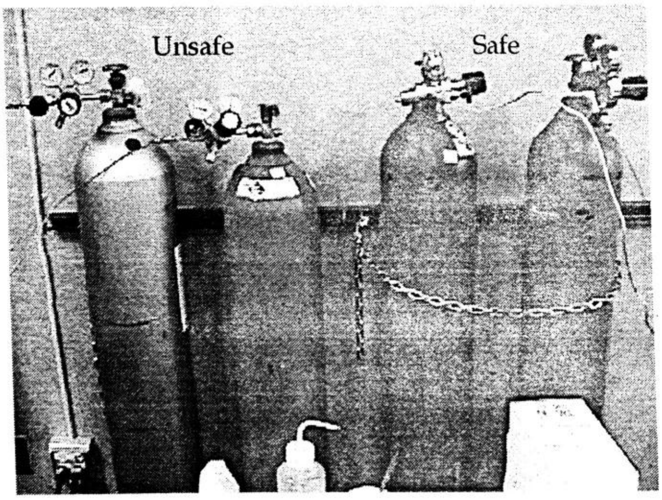
7. Personal protective devices should be used depending upon the nature of work viz. (a) Corrosion-resistant and impervious suits, or hand-gloves, aprons etc. (b) Respirator, gas mask or self contained breathing apparatus, (c) Barrier cream when exposure is not severe.

8. First aid treatment facilities should be provided and all concerned should be instructed to follow safe practices such as (a) Prolonged washing with water (b) Removing contaminated clothing (c) Seeking immediate medical help.

9. Safety showers and eye washers should be provided.

See also Schedule 12 and 19 under rule 102 of the Gujarat Fartnnp«i Rnips

8.4 Safe Storage & Handling of Gas Cylinders:



Cylinders should be tied by chain

In factories we find the use of gas cylinders of oxygen, nitrogen, acetylene, LPG, carbon dioxide, chlorine, sulphur dioxide etc. The gases are filled with pressure. Therefore when they leak, they come out with force and pose hazards of fire, explosion or toxicity. Therefore some rules are to be observed while handling them. They are stated below.

1. Following Indian Standards are useful for understanding design, construction, fittings, testing, safety devices, valves and use of gas cylinders:

IS	8198 (12 parts)	:	Code of practice for steel cylinders for different compressed gases.
IS	7241	:	Glossary of terms.
IS	5903	:	Safety devices.
IS	3224	:	Valve fittings.
IS	7202, 9199 & 9687	:	Threads of valves.
IS	4739	:	Identification of contents (Colour Code).
IS	6901	:	Pressure regulators for welding and cutting.
IS	8868	:	Periodical inspection.
IS	5845	:	Visual inspection for low pressure gas cylinders.
IS	8451	:	Visual inspection for high pressure gas cylinders.
IS	8433	:	Visual inspection for dissolved acetylene.
IS	3196 (3 parts)	:	For LPG, Steel cylinders for low pressure.
IS	8776	:	For LPG, valve fittings.
IS	8867	:	For LPG, vapour & test pressure.
IS	6044	:	For LPG cylinder installations.
IS	7680	:	For ammonia (anhy.) gas.
IS	7681	:	For chlorine gas.
IS	7312	:	For dissolved acetylene gas.
IS	7142	:	For low pressure liquefiable gas.
IS	7682	:	For methyl bromide gas.
IS	8016	:	Hand trolley for.
IS	5844	:	Hydrostatic stretch testing.
IS	3933, 3870 & 8382	:	For medical use.

2 Types of safety devices mentioned in IS 5903 are Bursting disc, fusible plug, PRV and their combination. It is prohibited to provide any safety devices on cylinders containing obnoxious or poisonous gases such as CO, HCI, HBr, HF, SO_2, CI_2, H_2S, town gas, Carbonyl chloride, Nitrosyl chloride, ,Nitrogen peroxide, Methylamine and Methyl bromide. Shut-off device (except built-in with safety device) is also prohibited.

Formulae for flow capacity of safety devices, identification and marking, number of test and test procedure and periodic inspection and maintenance are also specified in IS:5903.

3 Normal procedure to identify and classify (to put into a group) gas cylinders is to see their colours. See IS:4379 for this purpose. Commonly used cylinders are painted as under :

Acetylene	-	Maroon
Air, N_2	-	French grey.
Ammonia, CO_2, O_2, Phosgene	-	Black
Argon, HCN,	-	Peacock Blue.
Butane, Methane, Propane, LPG, CO, H_2, Coal gas	-	Signal red
Chlorine	-	Golden yellow
Ethylene, EO	-	Dark violet
Helium, Neon	-	Middle brown.

SO_2 - Light brunswick green.

Ground colour prescribed for flammable/ non-flammable and poisonous/ non-poisonous gas or mixture is white. Colour code is also prescribed for specific gas mixtures.

Thus specific colour indicates specific gas. Therefore die colour shall never be changed. If colour is washed out, rubbed or not clear, write the name of the gas on the cylinder or on a tag tied to it. In one factory, a worker joined an oxygen cylinder instead of nitrogen cylinder to a reaction vessel containing explosive mixture. It resulted into fire, explosion and death of another two workers. A mistake in handling can cause such serious accidents.

4. First verify the marking, number, company, pressure, weight, capacity and date on the cylinder before their use.
5. Cylinder should be handled in its special trolley or gently rolled on its bottom edge but not on the whole surface. It should not be thrown or .subjected to undue force for damage. Lifting machinery or magnet should not be used to lift them. While carrying a chlorine tunner (or any heavy cylinder) in a forklift, it should be tied with a chain to prevent rolling.
6. Long vertical cylinder should be kept upright in its stand or tied with chain to prevent falling.
7. No flammable material should be allowed nearby. Source of ignition, spark, flame, electricity, molten metal etc. must be kept away. Cylinder should not be used as earthing. It should be protected from excessive heat, cold, dampness and corrosive chemicals.
8. When not in use, the valve should be kept closed and covered with cap. If the valve is leaking, it should be repaired by an expert or trained man, otherwise the cylinder should be shifted in a remote open ground.
9. Pressure regulator (double regulators for pressure > 800 psi), pressure gauge and non-return valve (NRV) should be maintained in working order. Special spanner may be used to close or open the valve keeping the thread direction in mind. The spanner should be kept nearby.
10. Grease or lubricating oil should not be applied on valves of oxygen cylinders.
11. A store-room of gas cylinders should be well ventilated. Filled and empty cylinders should be kept separate. Construction should be fireproof if flammable cylinders are to be stored.
12. Before testing a cylinder, it should be carefully depressurised. Valves should not be interchanged
13. Pipelines connected with cylinder should be kept according to the pressure and type of gas. Flexible plastic pipe for toxic or highly flammable or explosive gas (e.g. Hydrogen) should be avoided or tightened properly and replaced in time. One worker died on the spot due to explosion when hydrogen leaked from the joint of a plastic pipe. Valve should be opened gently and only as per requirement.
14. Leakage of flammable gas may be checked by a soap solution and air bubble (not by naked flame or lighter), ammonia by sulphur dioxide and chlorine by ammonia water. Their bottles (torch) should be kept ready. No leakage should be checked by nose.
15. Quantity of cylinders should be restricted. If toxic and flammable cylinders are kept in the same shade, a partition wall should be provided. A blast wall is necessary for highly explosive cylinders. In a storage of flammable cylinders electric wiring/fitting should be flameproof and 'No Smoking' notice should be displayed. Earthing should be double and well maintained. Fire extinguishers, emergency kit and PPE should be kept ready. If the storage is in open land, a wire fencing and locked door should be provided.
16. Gas flow-rate may be known by providing flow meter or placing the cylinder on a weighing platform. Flow-rate should not be excessively increased.
17. The metal of adopter on a valve should be the same as that of the valve to prevent erosion of threads.

18. While connecting or changing a cylinder, necessary respirator and eye goggles shall be worn. First the cylinder valve shall be closed and then lhe process (header) valve. This will disallow any gas to remain in-between.
19. For emptying the residual gas, the cylinder shall not be heated. This needs a suitable vaporiser plant.
20. Provisions of Gas Cylinder Rules and SMPV Rules shall be followed. See Part 3.5 and 3.6 of Chapter-28.
    For chlorine cylinders, see Part 8.6.1.

8.5 Design of Storage Shed & Placement of Containers.

Storage safely requires appropriate design and approval from authorities. Many dimensions and criteria are prescribed in statute books, codes and standards. Some guidelines are also available from the supplier of materials. All such instructions are to be utilised from the design stage. Storage sheds should be constructed as per structural guidelines. Their safety and stability are important.

There are different designs of storage shades. Some are open from all sides while some are closed. Floor design, doors, windows and ventilators should consider properties of the materials to be stored. Floor slope on one side or at the centre, upper ventilation for low vapour density, lower ventilation for high vapour density, fire detectors at proper location, surrounding open space for easy movement, sufficient head room for fire fighting, proper stacking, racks and ladders to reach at height, proper lamps or tubes for sufficient lighting, proper air conditioning and maintenance of low temperature for storage of low boiling liquids, floor slope connected with drain and collection pit or retention basin, proper entry and exit ways, cross ventilation for comfortable temperature and dilution of air, sufficient roof height and proper roof design to maintain proper ventilation and temperature inside the shed and drain away raining water, alarm system in case of fire and leakages, proper locking system for explosives and poisonous chemicals, etc. are some of the factors which should be considered while designing a storage shed. Sufficient fire extinguishers should be kept nearby. Fire hydrant should be available near the periphery of the shed.

Placement of containers should be safe and with sufficient spacing in between and surrounding. Barrels of liquids should be kept on wooden support. Chlorine toners should be kept on rail or rollers so that they can be easily moved. Proper mechanical lifting devices should be provided. Bags and boxes should be stacked in such a way that they should not fall. .Gas detectors with alarms- should be provided to detect leaking gases. Gas cylinders should be stored at separate place and away from heat generating sources. Identification plates should be displayed properly.

8.6 Safe Storage and Handling of Chlorine, Ammonia, LPG, EO and Oleum

Safety aspects of storage and handling of some commonly used chemicals are stated below.

8.6.1 Handling and Storage of Chlorine

Properties of chlorine are : Greenish yellow gas, liquid or rhombic crystals, mp - 101 °C, bp - 34.5 °C, d 1.47 at 0°C (3.65 atm), vp 4800 mm at 20 °C, vd 2.49, TLV 1 pptn, STEL 3 ppm and TC_{L0} (human) 15 ppm. In addition to toxicity, it poses fire hazard when react with turpentine, ether, ammonia gas, hydrogen, powdered metals, polypropylene, wax, rubber, acetaldehyde, acetylene, alcohol and many materials. When heated, emits toxic fumes. When reacted with water or steam, produces toxic and corrosive fumes of HCI.

(A) Employee Selection and Training :

Persons affected with asthma, bronchitis chronic lung conditions, and irritations of the upper respiratory tract should not be employed where exposures to chlorine might occur. Training classes for both new and old employees should be conducted periodically to keep them conscious and informed of the hazards. They should be instructed and trained to adopt preventive measures in case of emergency and to use safety equipment.

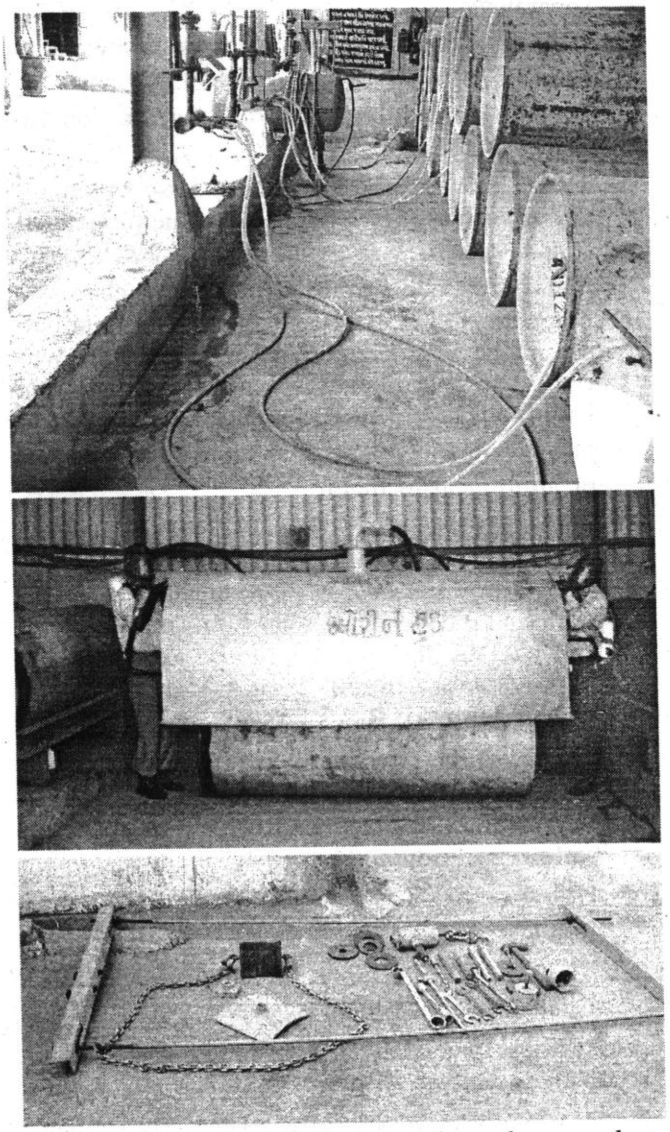
(B) Leakage tools:

1. Do not use water directing on leak.
2. Keep "emergency kits' handy and in proper working condition to control chlorine leakage and train workers in their use.
3. Appropriate facility for chlorine absorption through caustic soda/lime/soda ash solutions should be established and maintained in the event of leakage. The containers should not be immersed in same absorption media.
4. Ammonia water torches should be located at nearby places where chlorine containers are generally received, stored or used in process so as to facilitate easy detection of any leakage by white fumes.
5. Self-breathing apparatus, gas mask and 'emergency kits' should be located at strategic points under working condition and to be easily accessible in the event of emergency.

(C) Storage Area:

1. Storage area should be cool, dry, well ventilated, clean and protected from external heat source.
2. It should be remote from elevators, gangways or ventilating systems.
3. Ventilation must be sufficient to prevent accumulation of vapour pockets. All fan switches should be outside the storage area.
4. As far as possible, the building for the storage of chlorine should be entirely of non-combustible construction and separate from other building. In case the storage is not in a different building it should be ground floor with at least two exists opening outside and separated from other parts of the building by fire resisting walls and floors.

(D) Cylinders – Toners / Containers



1. Store chlorine cylinder up-right and secure them so that they cannot fall.
2. Ton containers should be stored on their sides on rails a few inches above the floor. They should not be stacked or racked more then one high.
3. Keep enough space between containers so that all are accessible in case of emergency.
4. Store the containers in a covered shed only. Keep them away from hot sun or any other source of heat.
5. Do not store chlorine container with explosives, acids, turpentine, ether, anhydrous ammonia, finely divided metals or other flammable material.
6. Cylinders should be stored on a cement floor sloping towards a pit capable of collecting all the liquid in the cylinders. Under no circumstances should water be allowed to run on to the chlorine in the pit.
7. Do not store containers in wet and muddy areas.
8. Use cylinders in order of their receipt.
9. Filled and empty cylinders should be stored separately.
10. Protective covers for valves should always be secured, even when the cylinders are empty.
11. No oil or any lubricant should be used on any valves of the containers.
12. The correct tool should be used for opening and closing valves, they should never be hammered

13. Cylinders should never be lifted by means of the metal cap, nor should rope slings, chains or magnetic device be used. The ton containers should be handled with a suitable cradle with chain slings combination with a hoist or crane having at least 2 metric tonnes capacity.
14. Never tamper with any fusible plugs of tonners or apply heat to them.

(E) Bulk Storage:

1. Being a compressed gas, all installations and tank vehicles used for storage and transport of liquid and gaseous chlorine have to be approved and licensed under the Static and Mobile Pressure Vessels (unfired) Rules 1981.
2. Appropriate minimum safety distances as stipulated in the above mentioned rules have to be maintained from buildings or group of buildings or adjacent property.
3. The tank has to be installed entirely above ground.
4. The bulk storage tanks for chlorine should be installed near waste-air system.
5. At least two safety valves should be connected to the waste-air system.
6. Pressure indicator with alarm should be available in the control room.
7. As an emergency measure, a perforated pipe, connected to the blower suction, around the storage tanks can be laid. In case of leakage the leaked chlorine will get sucked through this pipe which leads to waste-air system where it can be neutralised.
8. Safe bulk storage of chlorine call systematic inspection and maintenance.

(F) Handling Through Pipelines :

1. For piping dry chlorine, the material of construction generally used is carbon steel. Piping arrangements should as simple as possible.
2. The number of screws or flange joints should be kept to minimum.
3. Piping system should be well supported-and adequately sloped to allow drainage and low spot should be avoided.
4. Suitable allowance should be provided for pipe expansion due to changes in temperature.
5. Cleaning may be accomplished by pulling through each length of pipe a cloth saturated with trichloroethylene or other suitable chlorinated solvents.

(G) Emergency Measures:

1. In case of leakage or spillage, any person tackling of chlorine should be equipped with emergency kits, self breathing apparatus or masks and other appropriate items of personal protection.
2. In case of major leakage, all persons including neighbour (depending upon the situation) should be warned. Take the leaking cylinder to an isolated open place and roll it in such position so-that the leaking point is on the top. In such case only gas and not liquid will escape.
3. Approach from the windward side so that the escaping gas can be carried downwind to a lower level. In no circumstances should water or other liquid be directed towards leaking containers, so as to disperse the gas. Also the water solubility of chlorine is more at low temperatures, it will dissolve readily in the chilled water.
4. In case of large leaks, try to stop die flow of liquid by closing the valves.
5. After containing the liquids, one can use fluroprotein foam to prevent evaporation of the liquid.
6. In case of large leakage, the alternate solution is to absorb the chlorine in an alkaline medium such as caustic soda, soda or lime slurry. .

8.6.2 Handling and Storage of Ammonia

Properties of Ammonia are : Colourless gas, pungent odour, mp - 77.7 °C, bp - 33.35 °C, LEL 16%, UEL 25%, d 0.771 g/1 at 0 °C, vp 10 atm at 25.7 °C, vd 0.6, TLV 25 ppm, STEL 35 ppm, LC_{L0} (human) 10,000 ppm for 3 hrs, TC_{L0} (human) 20 ppm - irritant. Fire hazard low. Explosion hazard moderate when exposed to flame. When heated emits toxic fumes. To fight fire, stop flow of gas.

(A) General Preventive Measures

1. Designing of layout of area with due consideration of adequate natural or mechanical ventilation.
2. Use of properly selected material for construction of plant and equipment for handling of ammonia.
3. Preventive maintenance of all equipment in proper working condition.
4. Avoid contact of ammonia\ with certain other chemicals, including mercury, chlorine, iodine, bromine, calcium, silver oxide and hypochlorite.

(B) First Aid:

1. Keep trained first-aiders having the knowledge in the use of first aid equipment.
2. Provide necessary showers, eye-baths and oxygen administration apparatus.
3. Suitable notices should be fixed in convenient places regarding first aid measures.

(C) Personal Protective Equipment :

Provide adequate-and suitable personal protective equipment at all times e.g. gas-tight chemical goggles, self contained breathing apparatus, positive pressure hose masks, air line masks, chemical cartridge respirators, hard hats, soft-brimmed hats or caps, safety-toed rubber boots, rubber gloves, rubber apron or rubber coat, sleeves and trousers legs, etc.

(D) Leakage Tools:

1. Use large volumes of water directing on leak.
2. Leaks of a ammonia should be searched for, preferably with Hydrochloric acid solution or with a small cylinder of the compressed SO, gas. Because of the fire risk, sulphur candles should not be used.
3. Gas masks should be located at strategic points under working condition and to be easily accessible in the event of any emergency.

(E) Storage and Handling Controls :

Indoor Storage:
1. Storage should be cool, dry, well ventilated and protected from external heat sources.
2. The building protected with automatic sprinklers, vapour tight electrical equipment, good natural ventilation, good floor drainage and adequate exposition venting.

Outdoor storage:
The location should be away from any flammable liquid storage.

Bulk Storage:
1. In case of multiple storage facilities, a plan should be prepared for readily and definitely approaching all shutoff valves to be used for isolating various parts of the storage facilities.
2. Each storage area should be protected at least by one standard fire hydrant.

3. Gauge of glass should be provided with excess flow check valves. The Gauge glasses should not be longer than 120 cm and more than 60 cm between supports.
4. Storage tank construction should be of integrity and double wall type known as 'can in tank' type.
5. Each storage tank shall be equipped with two relief valves mounted on a 3-way hand valve to provide means for repair of faulty valve.
6. Install remote controlled valves at the bottom of ammonia storage tank.
7. Facilities for creating water curtains around the ammonia storage tanks should be created to absorb ammonia vapours if they leak .out, however, care should be taken not to add water to the liquid ammonia else it will worsen the situation.
8. Non refrigerated ammonia shall be stored in gas tight containers.
9. In the event of power failure, provision should be made to run the holding compressors of all the ammonia storage by emergency diesel generating sets so as to compress excess vapour into liquid ammonia (for refrigerated bulk storage system)
10. A flare stack should be provided to burr ammonia vapour in case safety valve fails to release ammonia pressure.

8.6.3 Handling and Storage of LPG

After Chlorine and Ammonia, the third chemical of major industrial use is LPG i.e. liquefied petroleum gas. As LPG, propane and butane are widely used as fuels. LNG, liquefied natural gas, is mainly methane. It is stored as liquid and transmitted by high pressure pipeline for industrial and domestic uses. NGL, natural gas liquids are mainly ethane, propane and butane. They are also transmitted by pipeline. Fire and explosion are the main hazards associated with them Boiling points and explosive limits of these hydrocarbons are as under :

Properties & Hazards of LPG :

No	Gas		BP oC	LEL %	UEL %
1	Propane	LPG & NGL	-42.1	2.3	9.5
2	Butane		-0.5	1.9	8.5
3	Methane	LNG	-161.5	5.3	15
4	Ethane	NGL	-88.6	3.0	12.5
2.05	Ethylene		-103.9	2.7	36
6	Propylene		-47.7	2.0	11.1

Commercial butane (n-butane) and propane are used as LPG. They exist as gases in ambient condition but can be liquefied under little pressure and on release of this pressure, they again become gases. As liquid its density is 0.5 and will float and vaporise on water surface. Therefore water is not good extinguishing media for LPG fire but it is essential to keep the vessel cool. Its vapour density is 1.5 and does not disperse easily. It tends to sink to the lowest possible level and if ignited in a confined space, it can explode also. Bottom ventilation (holes) near LPG cylinder allows leaking gas to go outside. Its explosive range is 2 to 10%. Its flame can travel back to the source giving flash back. It can cause cold burns to the skin due to its rapid vaporisation and lowering of temperature. Its very high concentration in air, is anaesthetic and on dilution, it becomes asphyxiant. It gives odour at l/ 5th of its LEL (i.e. at 0.4% of gas in air). Heavy leaks give hissing sounder icing in the area of leak. Small leaks may be detected by soap solution (bubbling). Never use a naked flame to detect it.

Its empty tank may still contain LPG vapour and if air enters in empty tank (due to any opening or leaking of valve) it can form an explosive mixture. Therefore it must be purged by inert gas first and gas-test should be made before doing any work on it.

Location & other Safety Aspects :

LPG tanks can be sited above or under ground. In any case the manhole and the safety valves should remain in open well ventilated position. Guidelines of Explosive Act & Rules, SMPV Rules, Petroleum Act & Rules and Controller of Explosives must be followed (See Part 3 of Chapter-28).

LPG vessels should not be located one above the other. The ground underneath should be concreted or compacted and free from pits, drains and culverts. Weeds, grass, shrubs, tress or any combustible material should be removed from the ground. Separation distances are mentioned in Table

Table 18.6 : Spacing of LPG Vessels

<table>
<tr><th colspan="2">Tank capacity in</th><th colspan="5">Separation Distances in mt</th></tr>
<tr><th rowspan="2">Tonnes</th><th rowspan="2">Litres x 1000</th><th colspan="3">Above Ground Vessels</th><th colspan="2">Under Ground Vessels</th></tr>
<tr><th>From surrounding or source of ignition</th><th>With fire wall</th><th>Between vessels</th><th>From surrounding or source of ignition</th><th>Between Vessels</th></tr>
<tr><td>0.05-0.25</td><td>0.15-0.5</td><td>2.5</td><td>0.3</td><td>1</td><td>0.3</td><td>0.3</td></tr>
<tr><td>0.25-1.1</td><td>0.5-2.5</td><td>3</td><td>1.5</td><td>1</td><td>1</td><td>1.5</td></tr>
<tr><td>1.1-4</td><td>2.5-9</td><td>7.5</td><td>4</td><td>1</td><td>3</td><td>1.5</td></tr>
<tr><td>4-60</td><td>9-135</td><td>15</td><td>7.5</td><td>1.5</td><td>3</td><td>1.5</td></tr>
<tr><td>60-150</td><td>135-337.5</td><td>22.5</td><td>11</td><td rowspan="2">0.25 x sum of dia of 2 adjacent vessels</td><td>3</td><td rowspan="2">Depending on site conditions</td></tr>
<tr><td>>150</td><td>>337.5</td><td>30</td><td>15</td><td>3</td></tr>
</table>

Slope should be given to the ground beneath the vessels, connections and equipment containing LPG to drive away any dripping or leakage towards a safe area. Such evaporation area or catchments pit should be at least 3 m from LPG vessels and have sufficient capacity to contain the largest credible leak and well ventilated to permit safe dispersion. Gas detectors should be provided in the pit to give warning of any LPG vapour.

For other details of fire walls, mechanical integrity, certification, marking, fittings (safety valves, drain connection, level gauges, valves, pumps and compressors), piping, vaporisers, security, fire precautions, loading and unloading facilities, commissioning and decommissioning, maintenance and examination, operational procedures and training see the reference no. 41 at the end.

Minimum safety distances are also given in IS:6044 (Part 2) for LPG storage and installations. Part I is for LPG cylinder installations.

8.6.4 Handling and Storage of EO

Properties of Ethylene oxide are : Colourless gas, mp - 111.3 °C, bp 10.7 °C, LEL 3%, UEL 100%, fp -17.8 °C, d 0.8711 at 20 °C, vp 1095 mm at 20 °C, vd 1.52, TLV I ppm, LD,, (rat)' 330 mg/kg, LC, (rat) 1462 ppm for 4 hrs. It is toxic, flammable and explosive. Fire & explosion hazard when exposed to heat or flame. To fight fire use CO_2, DCP or alcohol foam. It can react with acids and bases, alcohol, $AICI_2$, Al_2O, $FeCl_3$ Fe_2O_3, ammonia, copper, mercaptans, potassium, tin chlorides etc. Vaporises rapidly at ambient temperature, can cause cold burns and it is soluble in water.

PVC gloves, aprons, gum boots, goggles or face shield and breathing apparatus are necessary equipment to handle EO.

Safety Measures : Avoid heat, flame and ignition sources. Dilute spillage with plenty of water. Provide N, blanketing and preferably keep storage tank refrigerated. Its pressure should be kept within operating limits. Equipment cleaning may be done by citric acid. Prevent backflow of any chemical into the EO vessel.

Storage tank should be separated at least 15 mt from plants and buildings. Collusion of vehicles should be prevented by fencing and barricade. Spillage should be directed to a remote catchpit by an impermeable and sloppy floor.

It polymerises by iron rust, acids, bases and by chlorides of iron and other metals. Polymerisation is highly exothermic and may result in explosion.

Material of construction - stainless steel or MS aluminised from interior. Insulation - mineral wool covered by galvanised or SS cladding. Gaskets should be teflon coated.

Level gauges are float differential pressure type, torque tube type or magnetic float type. Compound pressure and vacuum gauge is preferable. Temperature gauge with high and low temperature alarm necessary. Double safety valves (at least one must be locked open) with 2 mt discharge outlet pipe, flame arrester on outlets and N_2 purging connections are required. Lines should not be of less than I inch diameter. To prevent reverse flow of EO, NRV and double block and bleed valve system is required.

In emergency, start water spray system or circulate chilled water through limpet coils or use fire water hydrant system. Knock down vapours with water spray and dilute continuously with water spray nozzle.

Pump temperature should not rise 3 °C. Therefore it should be kept cool by recycle from delivery to suction. A centrifugal pump with mechanical seal is normally used. If temperature margin (3 °C) increases, the pump should be stopped.

To avoid accident of EO road tankers, provide driver with TREMCARD, DCP extinguisher, PVC hand-gloves and respirators. In extreme case, EO may be transferred from one tanker (which cannot be pulled out or run) to another by using N_2 cylinders.

8.6.5 Handling and Storage of Oleum

Properties of Oleum are : It is a fuming heavy, yellow liquid (sulphuric acid) as H_2S0_4 + upto 80% $S0_3$. Mostly it comes in two categories : Oleum 23% i.e. in 100 kg, 23 kg SO_3, and 67 kg H_2SO_4 and Oleum 65% i.e. in 100 kg, 65 kg SO_3 and 35 kg H_2SO_4. It is highly irritant to skin, eyes and mucous membranes and via oral and inhalation routes. It can cause dangerous fire hazard by chemical reaction with reducing agents and carbohydrates. It can cause explosion also by chemical reaction with acetic acid, acetic anhydride, acetonitrile, acrolein, acrylic acid, aniline and many other chemicals. When heated to decompose, it emits highly toxic fumes of SO_2 (TLV 2 ppm and STEL 5 ppm). It reacts with water or steam to produce heat and toxic & corrosive fumes. TLV 1 mg/m^3

Dyke with slopped ground floor is required to contain storage tank(s). Acidproof lining in dyke -is necessary. Tank vent is to be connected with a sulphuric acid tank or scrubber with strong H_2SO_4 to prevent discharge of fuming SO_3. Ventline of oleum of more than 45% concentration needs steam tracing to prevent freezing of SO_3. A roof is required to protect from rain water. Nearby safety shower and eye washer is necessary for workers to dilute splashes or burns. To contain spillage ample quantity of sand or slaked lime or sodium carbonate should be kept aside. Water or wood dust should not be sprayed on leaking oleum. Self-breathing apparatus and acid-proof hand-gloves, aprons and gum boots are necessary. Level indicator and identification of content are also necessary. Remote control isolation valve at the bottom outlet or no bottom outlet and submersible pump on the top outlet are desirable.

Compressed air (free from oil, moisture and other impurities) is used to unload the tanker. The tanker outlet valve should be made of SS with teflon coating and leakproof. Air pressure data for a specific unloading rate is available from published literature.

DCP extinguishers are useful on small fires of oleum. Workers need training to attend emergencies due to oleum leakage.

9 PROCESS HAZARDS AND CONTROLS

9.1 Types of Processes and Operations

Generally in a chemical plant processes are classified as batch processes or continuous processes or their combination. In a batch process relatively more man-power is required, the workers are exposed to hazards more frequently and process automation and instrumentation are possible only to a limited extent. A continuous process is carried out in a closed vessel or circuit and good automation and instrumentation are possible. Many processes are operated at high pressure and high temperature (as incase of petroleum and petrochemical industry) for which automatic warning, monitoring and controlling devices are desired. Pressure and temperature should be properly controlled by cooling and safety devices. Flammable, explosives and solvent distillation processes should be carried out under inert atmosphere or vacuum and toxic processes should be connected with appropriate scrubbers and neutralisers.

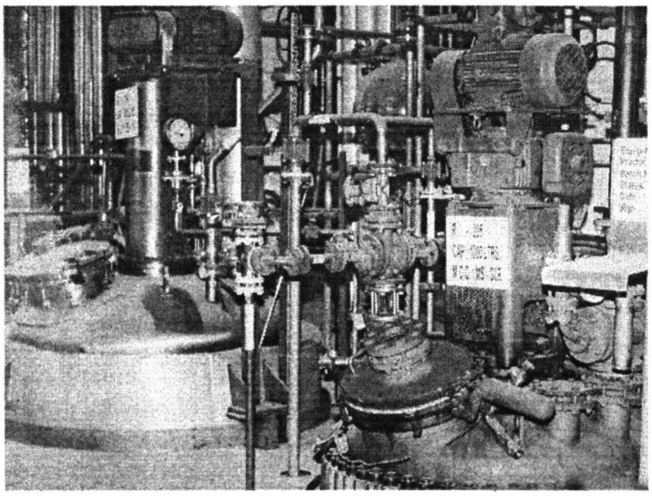
Study all unit processes arid unit operations with complete reaction documents i.e. all reaction data of intermittent behaviour as well as escaping behaviour out of the controlled parameters. This requires precise laboratory study and much details of side reactions, unwanted runaway reaction, generation of any flammable or toxic vapour, fumes, gas etc. or generation of abnormal pressure, temperature, expansion, contraction etc. at any stage of the process in control or out of control and adversely affecting the people or environment. Based on this, all necessary safety measures must be kept ready and provided to keep the reaction in control and to control again in the event of their going out of control also. Processes of exothermic and high pressure reaction, solvent distillation, distillation of toxic substance, polymerisation/chain reaction, , gas generation, filling etc., petroleum processing, autocatalytic reaction, decomposition, undesired reaction with other media, operating in or near explosive range, process of combustible material, process of toxic material , dust/ fume/gas process and process difficult to control need much attention.

Reaction Rate must also be controlled. The reaction rate is determined by the rates of the forward, reverse, and side reactions and by the rate of diffusion of the reactants. Intensity of heat supply, mass transfer coefficient, rate constant of a process, driving force of a process, pressure, temperature, catalysis, mixing or addition, stirring, time etc. are some important parameters to be controlled. Heat, material and energy balances must be understood properly. In practical terms 10 °C temperature rise may double the reaction rate. The reaction heat tends to accelerate the reaction and leads to runaway if cooling system is inadequate or fails suddenly. Many accidents have been noticed in such cases. Oxidation of hydrocarbons, nitration an polymerisation are some typical examples.

If quantity (mass) of chemical, its concentration or addition rate are changed (knowingly or unknowingly), violent or explosive reaction may take place. Therefore it is safer to keep quantity concentration and temperature as low as possible Reaction inhibitors and negative catalysts are used to reduce the activation energy.

The processes are also classified as unit processes and unit operations. They are explained below briefly :

9.1.1 Unit Processes



In such processes, by combination (chemical reaction) of two or more chemicals, a new product (compound) is formed. It indicates a chemical change.

Alcoholic caustic fusion : Reaction carried out a lower temperature (105-130^{0}C) using caustic soda o) potash and alcohol (like ethanol, methanol,, cellosolve, isobutanol).

Amination : Introduction of amino group in the molecule using liquid ammonia or any other aminating agent.

Caustic fusion : Reaction carried out in molten caustic potash/caustic soda at temperature above 150^{0}C.

Condensation : Reaction in which two or more molecules combine with the separation of water or simple substance.

Halogenation : Introduction of chlorine or bromine in the molecule using calcium hydroxide etc.

Hydroxylation : Introduction of hydroxyl group in the molecule using calcium hydroxide etc.

Nitration ; Introduction of nitro group in the molecule using nitric acid or mixed acid.

Oxidation : Introduction of oxygen or removal of hydrogen from the molecule using oxygen liberated by the action of acid and substance rich in oxygen.

Reduction : Introduction of hydrogen or removal of oxygen from the molecule using hydrogen liberated by the action of acid and metal.

Sulphonation : Introduction of sulpha group in the. molecule using sulphuric acid or oleum or chlorosulphonic acid.

Some hazardous unit processes are given in Table ton

Table 18.7 : Unit Processes with examples

	Unit processes	**Process Hazard**	**Application**
1	Alkylation Ex – Butylene + isobutene iso-octane	Exothermic, side reactions	Petro and organic chemical.
2	Animation by aminolysis Ex – EDC + Ammonia Ethylene diamine	Gas phase pressure reaction, Exothermic	Dyes, organic chemicals, synthetic fibres
3	Ammoxidation Ex- Propylene + ammonia + air acrylonitrile	Exothermic, toxic effect	Plastics, synthetic fibres
4	Carbonilation Ex – Methanol + CO acetic acid	Exothermic, toxic effect	Organic chemicals
5	Condensation Ex – Phthalic anhydride + benzene anthraquinone	Exothermic	Dye intermediates
6	Diazotisation & coupling Ex – Amine + HCl + O_2 Diazonium chloride	Exothermic	Dyes
7	Halogenation Ex – Ethylene + chlorine Ethylene dichloride	Highly exothermic	Organic chemicals
8	Hydrogenation Ex – Olefin + H_2 Paraffin	Exothermic	Fats, waxes, coal processing, petrochemicals
9	Hydrolysis Ex – Chlorobenzene + Water phenol	Exothermic	Organic chemicals
10	Nitration Ex – Benzene + Nitric acid Nitrobenzene	Highly exothermic, Explosive	Explosives, dyes, organic chemicals
11	Oxidation Ex – Alcohol + O_2 aldehyde + carboxylic acid	Highly exothermic, Explosive	Organic chemicals
12	Polymerisation Ex – Ethylene monomer + dimmer polyethylene	Exothermic	Petrochemicals, estomers, synthetic fibres
13	Sulphonation Ex – Benzene + H_2SO_4 Benzene sulphonic acid	Exothermic, Highly corrosive	Dyes, surface active agents

Some other unit processes are Acylation, alcoholysis, aromatisation or cyclization, calcination, carboxylation, causticization, combustion, dehydration, dehydrogenation, double decomposition, electrolysis, esterification, fermentation, Fischer-Tropsch reaction, Friedel-Crafts reaction, hydroformylation (oxo), hydration, ion-exchange, isomerisation, neutralisation, pyrolysis or cracking, reduction, saponification etc.

Hazards associated with unit processes/ operations are:

1. Mechanical hazards e.g. pressure release, leaks, burns, noise, .equipment or utility failure.
2. Reaction hazards due to failure to control exotherms, incompatible materials, side reactions, feed ratio or rate variation etc.
3. Environmental hazards such as air pollution, odour problems, spills etc.

Toxicity and health effects Flammability hazards due to explosive mixture, static charge, autoignition etc.

9.1.2 Unit Operations

In such operations, there is no chemical reaction to form a new product. It indicates no chemical change but mechanical or physical change like distillation, cutting, heating, cooling, drying, mixing, grinding, washing, packing, transferring, filtering, handling, radiation etc.

Some general operations in a sequence are as follows -
Steam distillation : Live steam is passed in the still to recover the solvent. Vapours of solvent and water are passed in a shell-tube type condenser and cooler. Then the cooled distillate are taken in a separator where solvent and water separate out and are diverted to respective storage. .

Heating : Heating operation can be done either directly or indirectly. In direct heating, steam is passed in the material directly to heat the material. In indirect heating, heating media (e.g. steam, hot oil, hot flue gases etc.) are passed in jacket / coil of the vessel.

Cooling : It can be done directly or indirectly. In direct cooling, ice or cooled water is added to the material directly. In indirect cooling, cooling media (raw water, chilled brine, cold oil etc.) are passed in jacket / coil of the vessel.

Drowning means transferring reaction mass from the reaction vessel to a tank which is containing water or other medium (e.g. dilute acid, dilute alkali etc.) Filtration : This operation is for separating solids and liquids. The conventional items used for this operation are press, nutch, centrifuge. The filtration can be done either under vacuum or pressure or at atmospheric pressure.

Pulverisation : This operation is done to reduce size of the material. Usually crushers, pulverises, ST mill are used.

Blending : This operation is done in a blender to mix thoroughly two or more dried products.

Washing : This operation is done in presses, nutches or centrifuge to remove soluble impurities and acid/alkali from the product.

Packing is filling up of finished product in the containers.

Storing of liquid raw materials : Bulk liquid raw materials which are received in tanker loads are emptied out in storage provided for this purpose.

Unit operations are classified as under :

1. **Mechanical unit operations -** (1) Size reduction (2) Size enlargement, mixing, agitation, blending and kneading and (3) Separations e.g. gravity settling, filtration, centrifugal, impingement, screening, jigging, magnetic, electrostatic, hydro and flotation.

2. **Mass transfer operations** - evaporation, distillation, absorption, humidification, extraction, leaching, crystallisation, ion exchange, adsorption, drying.
3. **Heat transfer operations** - conduction, convection, radiation.
4. **Material handling, transportation & conveyance** - pumping, compression, fluidisation and containerisation (solid filling).

Controls : Distillation operation needs trip and alarm device to stop heating as soon as cooling stops. In addition, the vessel should have a safety valve to discharge any accidental pressure. In centrifuging, blending, grinding, crushing, pulverising or sieving of any flammable or explosive substance, inert blanketing, earthing and avoidance of sources of ignition are essential. Where stirring and heating both are going on, stirrer failure alarm and a device to cut heat source, are necessary.

9.1.3 Other Processes and Operations

It is utmost important to understand chemical processes before understanding their safety aspects. Therefore some such processor are explained below in brief.

Absorption of gases : The solution of gases in liquids or absorption of gases by solids through the whole body. It is penetration or consumption of one substance by another e.g. scrubbing.

Adsorption : The adherence of a substance on a surface, the substance that adsorbs is adsorbent and that is adsorbed is adsorbate. It is relatively a slow penetration or consumption of gas or liquid particles through the surface of another substance mostly solid or liquid. It is used to remove colours, odours and water vapours through activated carbon, activated alumina, silica gel etc.

Bromination : A reaction in which -one or more bromine atoms are substituted for hydrogen atoms in an organic molecule.

Calcination : Strong heating, conversion of metals into their oxides by heating in air.

Carbonation : Treatment with carbon dioxide. Usually for formation of carbonates.

Catalysis and Catalyst : The alteration of the rate of chemical reaction, by the introduction of a substance (catalyst) that remains unchanged at the end of the reaction. Small quantities of the catalyst are usually sufficient to bring the action about or to increase its rate substantially.

Chain reaction : Any self-sustaining molecular or nuclear reaction, the products of which contribute to the propagation of the reaction, viz. nuclear fission.

Decomposition : The breaking up of chemical compounds under various influences e.g. by chemical action, by heat (pyrolysis), by an electric current (electrolysis), by biological agents (biodegradation) etc.

Distillation : The process of converting liquid into vapour, condensing the vapour and collecting liquid or distillate. Used for separating mixtures of liquids of different boiling points or for separating a pure liquid from a non-volatile constituent.

Electrostatic precipitation : A widely used method of controlling the pollution of air (or other gases). The gas, containing solid or liquid particles suspended in it, so that the particles are attracted to and deposited upon, the positive electrode.

Endothermic process : A process accompanied by the absorption of heat.

Evaporation : The conversion of a liquid into vapour, without necessarily reaching the boiling point, used in concentrating solutions by evaporating off the solvent.

Exothermic process : A process in which energy in the form of heat is released.

Extraction : The process of separating a desired constituent from a mixture by means of selective solubility in an appropriate solvent. Also used to describe any process by which a pure metal is obtained from ore.

Fermentation : A chemical change, brought about in organic substances by living organism (yeast, bacteria, etc.) as a result of their enzyme action.

Fractionating column : A long vertical column, containing rings, plates or bubble caps, that is attached to a still. As a result of internal reflux a gradual separation takes place between high and low boiling 'fractions' of a liquid mixture.

Freezing : Change of state from liquid to solid, it takes place at a constant temperature (freezing point) for any given substance under a given pressure (normally standard atmospheric-pressure).

Fumigation : The destruction of bacteria, insects and other pests by exposure to poisonous gas or smoke.

Hydrogenation : Subjecting to the chemical action of or causing to combine with hydrogen.

Leaching : Washing out a soluble constituent.

Neutralisation : The addition of acid to alkali, or vice versa, till neither is in excess and the solution is neutral.

Photochemical reactions : Chemical reactions initiated, assisted or accelerated by exposure to light.

Pyrolysis : Chemical decomposition by the action of heat.

Radiation hazard : The potential danger to health resulting from exposure to ionising radiation or the consumption of radioactive substance.

Stabilisation : The prevention of chemical decomposition of a substance by the addition of a 'stabiliser' or negative catalyst. 'Stable' means which cannot readily decompose.

Sublimation : The conversion of a solid direct into vapour, and subsequent condensation without melting.

Tanning : The conversion of raw animal hide into leather by the action of substances containing tannin, tannic acid, or other agents.

Vacuum distillation : The process of distillation carried out at a reduced pressure and boiling point. Vacuum lowers boiling point. It is useful for distilling high boiling and heat sensitive materials such as heavy distillates in petroleum, fatty acids, vitamins etc.

9.1.4 Exothermic Reactions

In exothermic reactions, heat is given out as reaction proceeds. This release of heat raises the temperature of reaction mass. Approximately for every 10°C rise in temperature, reaction rate doubles. Thus with increase in temperature, reaction proceeds faster and still more heat is given out. This chain of operations makes the reaction uncontrollable unless adequate arrangement for removing heat or pressure are provided in the reaction vessel. The reaction rate has to be gradually increased so that reaction does not reach runaway stage.

Examples of exothermic reactions are nitration, halogenation, amination, alkylation, oxidation, condensation; polymerisation, neutralisation, sulphonation, hydrogenation, hydrolysis, aromatisation and isomerisation.

Vessels of such reactions should be regularly tested by a competent person.

For highly exothermic reactions since temperature has to be increased very gradually, automatic programmes are provided which maintain a predetermined rate of rise in temperature and thus prevent the reaction from reaching runaway stage. In addition to safety valve, a rupture disc with drowining i.e. dump or surge vessel is provided to receive the entire reaction mass in case of overpressure and bursting of the rupture -disc. The pressure gauge, temperature gauge, high pressure/temperature alarm and heat source cut off device, quenching or process killing device, safety valve, rupture disc, drowning tank, cooling device, agitator, feed control, pressure controller, drain valve etc., should be regularly checked and properly maintained. Alternate water, power and pumps are required to maintain the necessary cooling system.

9.1.5 Pressure and Vacuum Reactions

Any vessel maintained at a pressure above I atmosphere is a pressure vessel. Suitable means of pressure release such as safety valve and/or rupture disc should be provided. Gases released from safety valve, if poisonous, should be scrubbed before venting to atmosphere. Flammable gases should be safely contained and cooled. Emphasis should be laid on proper design, maintenance and testing of pressure vessels. Their thickness should be periodically checked for corrosion, pitting etc., as laid down in Rule 61 of the Gujarat Factories Rules, 1963. Pressure gauge, temperature gauge, temperature regulator, safety valve, rupture disc, pressure reducing valve or regulator, drowning tank, drain valve, feed control, temperature control (heating, cooling control), agitator control and stoppage alarm, high pressure alarm, gas leakage alarm, safe vent after safety valve, flame trap, non return valve, excess flow valve or flow controller, quenching or reaction killing device, purging valve, drain pipe, by-pass pipe with valve, manhole, inspection window, level indicator, earthing, flame arrester, safe and sound jacket, water cooling of gland packing, cooling interruption alarm, automatic heat or feed cut off and regulating devices, remote control etc. should be provided as per requirement.

Pressure vessels should be designed as per standard code (e.g. IS:2825) and periodically tested by a competent person. In a solvent vacuum distillation, if vacuum breaks, outside air can enter and make explosive air mixture in the vessel. This may cause fire or explosion. To avoid this a vacuum failure alarm and at that time inert gas purging (device) is necessary.

On distillation vessel also, an alarm and safety valve are required to indicate any choking and release of any pressure.

See subsequent Part 15.4 for pressure vessels and their safety aspects.

9.1.6 Flammable/Explosive Reactions and Distillations :

Utmost care should be taken during storage, transport, handling and reaction of explosive and flammable materials. Bulk storage of these chemicals come under purview of Chief Controller of Explosives. Free fall of flammable liquids should be avoided. Suitable dip pipes should be provided. All lines carrying flammable materials must be bonded by copper clamps and earthed. Continuity should be periodically checked and resistance to earth should be less than I Ohm. Pumps handling these chemicals should have brass or non-metal impeller to avoid sparks due to friction. Flow velocity should not exceed 6 m/sec in pipeline to avoid static charge accumulation. Reaction of flammable chemicals including solvent distillation should be carried out at low pressure or under vacuum or inert blanketing. Even on distillation vessel, a safety valve or explosion vent should be provided to take care of any accidental pressure. Flare, condenser, vent gas condenser or incinerator should be provided if required.

Another danger to flammable solvents come from smoking and electric sparks. All electric fitting should be flameproof including lighting. During maintenance, use of ferrous tools should be avoided as it can give rise to sparks. Flame arrester and smoke detector should be provided. Fire extinguishers should be kept ready.

As far as possible flammable substances should be processed at low temperature (below flash point) and pressure. Dip feed pipe, slow and controlled addition (e.g. niddle valve), inert blanketing, vacuum, spark/flame avoidance, spark/flame detectors with alarm, no-smoking habit, good ventilation and training to workers are necessary.

9.1.7 Toxic Reactions

For handling acid, alkali and other toxic chemicals, workers must be provided with suitable protective appliances such as rubber or PVC hand gloves, gum-boots, safety goggles, apron etc. Suitable posters showing dangerous properties of these chemicals and safe working procedure should be prominently displayed. Arrangement for combating spills of these chemicals such as water shower or pipe for covering up should be available nearby. The workers should be trained in the use of these chemicals and safety equipment before giving responsible job independently. Suitable scrubbers, absorbers or neutralisers for inorganic gas or vapour and condenser for organic vapour should be provided and well maintained.

See Table-18.4 of this Chapter and Table-17 of Chapter-32 for scrubbers.

Scrubber line should be always open. If it is provided with a valve, the reactor should have safety valve to take care of any pressure built-up due to closer of the scrubber line valve or any choking" in that line. Interlocking of a scrubber line valve with the addition valve is necessary so that no addition of any hazardous chemical can be started in the reactor unless the scrubber line valve is open. Concentration of scrubbing media should be checked and always maintained. If scrubber stops, alarm should be available and the process should also be stopped. Leak detector with alarm, ventilation according to the vapour density of the material, open working space, local exhaust ventilation on toxic (e.g. pesticide) fumes and dusts, wind velocity and speed indicators, safety showers and eye washers, cautionary notices and medical examinations of workers are necessary.

The modern instrumentation and control devices, interlocks, trips and alarms, auto controllers, automatic process correction device, computer controls, DCS system, direct reading, display and correction system etc. should be provided as per process requirement.

For handling poisonous gases such as chlorine, ammonia, sulphur dioxide, phosgene, phosphine etc., workers must be trained before assigning them responsible jobs. They should be provided with suitable respiratory protection. Arrangement for good ventilation such as suction hood with scrubbing arrangement should be provided in the plant.

A chemical can enter our body through injection, inhalation or skin contact. Lead, mercury, aromatic solvents, nitro and amino aromatic compounds, benzene, toluene, chlorine, chromium etc., are a few examples which can find entry into human body through various routes. The workers must be suitably protected from exposure to such chemicals. Efficient exhaust system, scrubbers and suitable protective appliances to avoid body contact should be provided. Skin absorption is the most important route and least understood by the average worker. Worker education plays an important role in the proper use of PPE. Workers should be trained to wear proper PPE. After handling of dangerous chemicals, workers must change their clothing followed by bath with soap and water. Provision of safety shower within easy reach is essential.

Periodic medical examination of workers exposed to hazardous chemicals should be carried out. If worker shows any indication of poisoning due to chemical, suitable preventive measures should be taken.

9.2 Operational Deviations :

Working parameters of process materials or utilities should not be deviated. Sudden changes in pressure, temperature, flow, control system etc. or exceeding safe operating limit (e.g. pressure vessel) or permissible exposure limit (e.g. toxic release, noise, radiation etc.) can result in accidents. Sometimes low level (e.g. water level in boilers, oil level in heaters) is also hazardous. Sudden opening of valves cause surges, fluctuations and vibrations. Increased addition rate of nitric acid has caused many accidents.

If pump or compressor stops, temperature increases or decreases, cooling or scrubbing stops, material expands or contracts or runaway reaction takes place, then because of change in pressure, temperature, flow and level are also changing.

If heating or cooling stops, heat exchanger stops, charging system changes, stirring delays in starting or restarts after closure, it errs in adding material or catalyst is overheated, then because of change in temperature, pressure, flow and reaction rate are affected.

If feed material stops, vapour affects, pump stops, impurities settle, material freezes or polymerises, ambient temperature goes down or control valve block<s, then because of change in flow, pressure, temperature and level are also changing. If flow stops, reduces or leaks, accident can occur. Therefore pipelines and valves should be kept clean and without choking. Steam tracing (indirect heating) lines should be provided on pipelines carrying material which can freeze and result in no flow.

If flow changes, pump stops, vapour or blockage takes place, vacuum fails or by surging, foaming, heat expansion, siphoning, stirring or vibration level changes and because of change in level, pressure, weight and measure also change. Measuring tank, day-tank, flow control meter, feed control valve, level indicator and level alarm are useful in controlling level.

Because of errors, faults or lags in measurement, design, operating valve or seeing or recording process parameters or in instruments indicating pressure, temperature, level, flow etc. or in their settings or by stoppage of utilities, control systems change resulting in change in parameters. Testing .and monitoring of instruments/equipment and training of workers can reduce such 'errors.

Failure of vessel, jacket, pipe, joint, pump, gasket, blower, compressor, stirrer, controllers, computers, pressure relief devices, flare, scrubber, welding etc., can cause major or minor accidents. These can be reduced by good design and maintenance.

To prevent operational deviations as stated above, it is most important to pay attention on safety and control devices such as pressure relief devices, level and flow controllers, temperature controls, alarms/trips and interlocks, leak detectors, spark or flame arresters, flameproof fittings where necessary, slow and safe charging and stirring, slow heating and monitoring, dumping or emergency by pass system, fire detection and control system, preventive and rapid corrective maintenance, education and training etc.

Emergency Shutdown : Because of operational deviations as discussed above or any other reason or failure of safety and control device when emergency arises and the situation seems to be out of control or aggravating, it becomes necessary to shutdown the plant or part thereof. Following procedures are adopted for this purpose :

1. Cutting of heat source or starting of cooling.
2. Stoppage of adding new material.
3. Stoppage of mixing.
4. Dilution of internal substance or reaction mass.
5. Flooding by water if it is effective.
6. Inert gas (N_2) purging.
7. Emergency by pass (transferring the material).
8. Inactivating the catalyst.

The most suitable, effective and safe procedure should be selected depending on process.

9.3 Use of Vessels, Equipments & Control Room

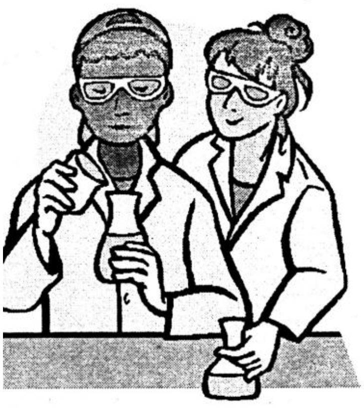
Many vessels and equipments are used in chemical processes. Storage vessels, reactors, distillation vessels, transfer vessels, holding *vessels, measuring vessels, open or closed vessels, pipelines and a variety of equipments are used as per design and need. Their material of construction (MOC) should be studied as stated in Part 8.1 for safety point of view. They should be used in enclosed manner as far as possible. Acids, alkali, solvents and dangerous chemicals should not be handled in open bucket or container. Schedule 19, Chemical Works, GFR should be strictly followed. Necessary PPE should be used.

Operation of valves and other control devices should be done carefully and as per guidelines and training. SOP should be followed.

Where automatic chemical processes are designed, a control room is provided. DCS and other fully or partially computerised systems are provided there. Training is necessary to operate such systems in the control room. Knowledge of different trips and alarms, interlocks, audio-visual indications and control of flow, pressure, temperature, etc. is necessary. Method of emergency shut down and emergency transfer should be known and safely followed. Vessels should not be subjected to over pressure, temperature, speed etc. Any abnormal deviation should be understood quickly and remedial measures should be applied in time.

9.4 Safety in Laboratory

Laboratory is used for testing of raw materials, intermediates and finished products. It is also used for research purpose. Glass vessels and other small vessels are used to handle small quantities of materials. Hazard of glass breakage should be understood and handle such vessels carefully. Screen and other guard should be provided. Rubber and flexible tubes should be checked frequently and replaced periodically. Their connections should be checked and kept leak proof. Laboratory vessels and reactors should never be subjected to over pressure, temperature, speed etc. Necessary PPE and apron should be used. Safety showers and wash basins should be provided for washing hands etc.



Fuming cupboards are provided for venting out fumes, gas etc. Their doors (shutter) should be kept closed up to the specified height. More opening will make the suction weak and gas/vapour may also come out.

Gas cylinders should be kept upright and tied with a chain for preventing their fall. Their valves and regulators should be properly used.

Waste collection bins or trolleys should be used to clean and collect wastes from the floor.

Batch sheets should be used for recording of the process and necessary instructions should be mentioned for the next shift worker if the process is to continue in the next shift.

Room exhaust and process exhaust systems should be provided and run efficiently.

Cupboards, shelves and racks are used to put small bottles, equipment etc. Necessary stool or support should be used while working with them. Laboratory should be kept clean, attractive and without any smell, dust or dirtiness

Safety and Emergency Equipment forth Laboratory

The following are checklists for safety an emergency equipment for the laboratory:

Personal Protective Equipment
1. Chemical splash goggles
2. Face shields
3. Lab coat
4. Lab apron
5. Gloves (selected based on the material being handled and the particular hazards involved)

Safety and Emergency Equipment
1. Hand-free eye-wash stations (not eye-wash bottles).
2. Deluge safety showers.
3. Safety shields with heavy base
4. Fire extinguishers (dry chemical and carbon dioxide extinguishers).
5. Sand bucket.
6. Fire blankets.
7. Emergency lights.
8. Emergency signs and placards.
9. Fire detection or alarm system with pull stations.
10. First-aid kits.

11. Spill control kit (absorbent and neutralizing agents).
12. Chemical storage cabinets (preferably with an explosion proof ventilation system).
13. Gallon-size carrying buckets for chemical bottles.
14. Laboratory chemical hood (60-100 ft/minute capture velocity, vented outside).
15. Ground-fault interrupter electrical outlets.
16. Container for broken glass and sharps.
17. Material Safety Data Sheets.
18. Emergency Action Plan for the institution.

General Rules for Chemical Storage

First, identify any specific requirements regarding the storage of chemicals from (1) local. State, and Central regulations and (2) insurance carriers.

Criteria for Storage Area

1. Store chemicals inside a closeable cabinet or on a sturdy shelf with a front-edge lip to prevent accidents and chemicals spills; a ¾ - inch front edge lip is recommended.
2. Secure shelving to the wall or floor.
3. Ensure that all storage areas have doors with locks.
4. Keep chemical storage areas off limits to all persons.
5. Ventilate storage area adequately.

Organization

1. Organize chemicals first by compatibility - not alphabetic succession.
2. Store alphabetically within compatible groups.

Chemical Segregation

1. Store acids in a dedicated acid cabinet. Nitric acid should be stored alone unless the cabinet. provides a separate compartment for nitric acid storage.
2. Store highly toxic chemicals in a dedicated, lockable poison cabinet that has been labeled with a highly visible sign.
3. Store volatile and odoriferous chemicals in a ventilated cabinet.
4. Store flammables in an approved flammable liquid storage cabinet.
5. Store water sensitive chemicals in a watertight cabinet in a cool and dry location segregated from all other chemicals in the laboratory.

Storage Don'ts

1. Do not place heavy materials, liquid chemicals, and large containers on high shelves.
2. Do not store chemicals on top of cabinets.
3. Do not store chemicals on the floor, even temporarily.
4. Do not store items on bench tops and in laboratory chemical hoods, except when in use.
5. Do not store chemicals on shelves above eye level.
6. Do not store chemicals with food and drink.
7. Do not store chemicals in personal staff refrigerators, even temporarily.
8. Do not expose stored chemicals to direct heat or sunlight, or highly variable temperatures.

Proper Use of chemical Storage containers

1. Never use food containers for chemical storage.
2. Make sure all containers are properly closed.
3. After each use, carefully wipe down the outside of the container with a paper towel before returning it to the storage area. Properly dispose of the paper towel after use.

10 UTILITY HAZARDS AND CONTROLS

Water, air, power, thermic fluid, fuel, steam/ heating media, brine/cooling media, inert gas/purging media, also need attention from safety point of view. Their failure creates immediate danger which requires similar immediate controls. Therefore compressors, condensers, emergency services, stand-by equipment etc., should be kept ready for immediate use.

Hazards of such utilities are not only because of their sudden failure, but also due to their working parameters like pressure, temperature, flow, leakage, dripping, toxicity, flammability and hazards of the vessels, piping, equipment and instruments through which they pass. Uncontrolled process or fire water may corrode the things, air pressure can burst a vessel or throw dust, thermic fluid leakage can cause fire or explosion, inert gas diminishes oxygen level for breathing and electric power and steam has, already caused many accidents. Refrigerant gas freon causes ozone depletion and thousands of tonnes of hydrocarbons and carbon dioxide emitted by fuel combustion, pollute the environment. Noise and vibration due to high flow of steam or air and other health hazards due to misuse of air, water, steam, electricity and nitrogen are also not uncommon.

In distillation column-condenser when cooling water stops, due to heat rise, pressure increases and bursts the condenser or sometimes causes back pressure in distillation vessel itself and bursts it. Pressure relief devices on such vessels, condensers and even on receivers are therefore necessary. High pressure/ temperature alarms interlocked with heat source to cut off the heat supply at predetermined pressure or temperature can work as safety devices. For quick cooling water supply, stand-by pump-motor set, DG set or overhead water tank to get water by static head only, are also necessary.

If there is a common water reservoir for process and fire water both, the suction pipe of the fire water pump should be deeper than that of the process water pump to allow a reserved stock of fire water for emergency.

Kettles, stills, jacketed vessels, evaporating pans and steam heaters where normally steam is utilised in jacket or heating coil, should be treated as pressure vessels for the purpose of safety. Their pressure parts should be provided with safety valve, pressure gauge and PRV. They should be tested by NDT and hydraulic testing and its records be maintained.

When a steam-jacketed vessel is completely valved off (vented), it should be protected with a vacuum breaker to stop collapsing. Where air is not desirable, N,, injection device should be provided. Before opening the vessel, first the jacket should be completely drained to make its pressure zero, and then the whole vessel should be allowed to cool. The jacket should be thoroughly drained before admitting steam into it because water in steam space may cause serious damage.

Autoclaves, vulcanisers, retorts, digesters etc. should not be opened before depressurising them. Their door should therefore be interlocked with the pressure.

In cold vessels, steam should be admitted slowly for slow and uniform heating and expansion of all parts. Steam valves should be opened slowly.

Where heating coils are used to heat water, oil or material, they should be kept submerged, the minimum liquid level should be maintained (by level gauge or low level alarm and automatic addition of the liquid) and the coil should be kept open at other end or be provided with a safety valve and steam-trap and should be checked for any choking.

Steam pipes should be insulated and claded. Steam leak can also cause static charge because of its jet action, therefore where steam is used to heat flammable material, steam pipes should be properly earthed and bonded.

For air cooling, heat exchangers and compressors mid for brine cooling and refrigeration, chilling plant mid insulation should lye properly provided.

Air being supplied to pneumatic equipment and respirators should be clean, dry, without dust, water or oil and at bearable pressure. Therefore air filter, pressure cut off switch, safety valve, pressure gauge and pressure regulator are necessary. Air receiver tanks should be tested hydraulically and their safety devices (SV, PG & PR) should be maintained properly.

Thermic Fluid Heaters : They are used to heat thermic fluid which is circulated in a closed loop through textile machines or chemical vessels requiring heat. Instead of steam, this oil is used because it can be heated to higher temperature and circulated at less pressure. It is less compressed and therefore stores less energy at the same temperature. Its main hazard is fire or explosion and can also cause hot burns if splashed. For statutory provisions see Rule 61D of the Gujarat Factories Rules

Coal, lignite, wood, furnace oil, diesel oil, LSHS, LPG, natural gas (LNG)etc. are used as conventional fuels. After combustion coal, lignite and wood (solid material) result in ashes and fly ash and dust particles cause health hazards and air pollution. They need costly control measures. To suppress coal dust and fly ash, water should be sprayed over them.

Some people burn rubber, plastic, paper and similar solid wastes (non conventional fuels) in boilers or furnaces. This is highly objectionable as it emits black smoke and carbon particles in surrounding, affecting neighbouring industries and public. In addition, it pollutes the environment. LPG or natural gas are clean fuels, give good thermal energy and less pollute the environment. Therefore their use should be preferred. LSHS, furnace oil and diesel oil stand in between. Economy and availability of fuel may have influence on selection, but however looking to the increasing air pollution, only eco-friendly fuels should be preferred. Storage tanks of fuels should be protected by safety devices discussed in foregoing Part 8.2.

Pipelines for steam, oil, water, air, fuel and chemicals should be arranged and protected properly. They should not cause any obstruction. Their supporting structure position and height should be safe and without risk. They should be painted with colours for protection and identification of hazards. Direction of flow should be indicated. Earthing, bonding, insulation, fittings (valves, regulators, gauges etc.) and joints should be as per requirement.

Electrical cables should be laid in trenches and in safe position i.e. away from furnaces, molten metal, chemicals, steam, water, hot oil or their splashes. Loose or hanging wiring must be avoided, joints if any, should be safe and sound so that they cannot be pulled out. Three pin top in plug, double earthing, charging of earthing pit, ELCB in power lines of portable tools, fuses of safe amperage and all electrical materials and fittings conforming IS mark are the basic requirements. For details see Chapter II.

Mixing of Utilities can cause hazards. Wrong operation of electric switch has caused fatal accidents. Mixing of steam or water in the jacket with reaction mass in the vessel, mixing of air with flammable material or mixing of toxic material with air or water arc all hazardous. Mixing of water in molten metal (e.g. induction furnace) or in reaction mass above 100 °C has caused serious accidents. Splashes of molten metal on electric cables has caused great fire resulting in damage of lacs of rupees. At very low temperatures (near "C or below), water .can freeze in pipelines and block it. Cyanides or pesticides mixed and drained with water can kill animals. Inert gas nitrogen has caused accidents. Playing with pressurised air, exposure to sudden splashes of steam, hot water or oil can also cause accidents. Therefore pipelines of utilities need sometimes double isolation or double block and bleed valves.

11 POLLUTION HAZARDS AND CONTROLS

Chemical industry discharges solid, liquid or gaseous wastes as a result of manufacturing process. Such wastes may be toxic, flammable, corrosive, radioactive, non-biodegradable or hazardous in nature and if it is not properly treated, it pollutes land, water, air and overall environment.

Water, soil/land, and air pollution create many problems and need efficient control. Effluent treatment plants and appropriate scrubbers, exhausts, flare, incineration and other neutralising or inactivating devices are most desirable. They must work for all working hours and in effective manner.

For environmental laws see part 10 of Chapter 28

12 INSTRUMENTATION FOR SAFE PLANT OPERATIONS

After understanding various types of chemical hazards in foregoing parts, we should proceed to know the instruments, equipment and other control measures.

To maintain, control, measure, alarm and record process parameters, various industrial instruments and safety devices are used. Their proper selection, application and maintenance are most important. Some basic instruments are mentioned below :

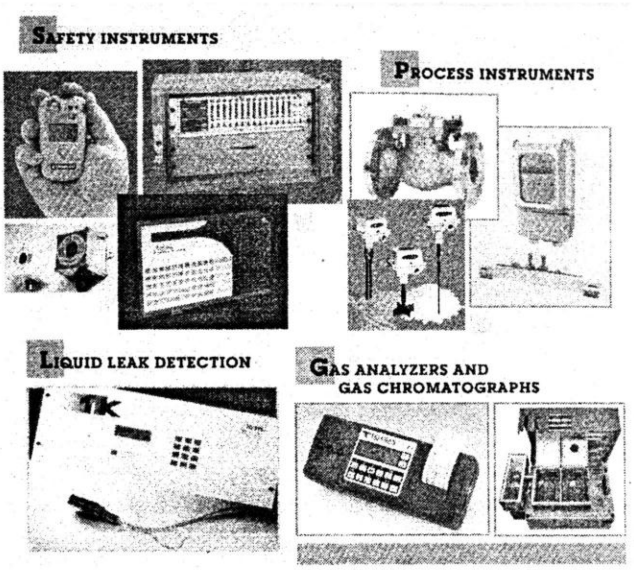
12.1 Basic Instruments

Anemometer	:	Instrument for measuring the speed of wind or any other moving gas.
Atmometer	:	Evaporimeter. An instrument for measuring the rate of evaporation of water.
Barometer	:	For measuring atmospheric pressure.
Barograph	:	Used in meteorology for recording on paper the variations in atmospheric pressure over a period of time.
Bolometer	:	An extremely sensitive instrument for measuring heat radiation.
Bomb calorimeter	:	A strong metal vessel used for measuring heats of reaction, especially heats of combustion, e.g. for determining the calorific value of a fuel.
Bourdon Gauge	:	A pressure gauge for steam boilers etc.
Calorimeter	:	For determining quantities of heat evolved, absorbed or transferred.
Cryometer	:	A thermometer especially designed for measuring low temperatures.
Dasymeter	:	An instrument for determining the density of a gas.
Dilatometer	:	An apparatus used for measuring volume changes of substances.
Hydrometer	:	For measuring the density or relative density of liquids.
Hygrometer	:	For measuring the relative humidity of the atmosphere.
Manometer	:	For measuring gaseous pressure.
Pyknometer	:	An apparatus for determining the density and co-efficient of expansion of a liquid.

Pyrometer	:	For measuring high temperatures.
Rotameter	:	A device to measure the rate of flow of fluids.
Salinometer	:	A type of hydrometer used for determining the concentration of salt solutions by measuring their density.
Seismograph	:	For recording earthquakes and phenomena associated with them.
Spectro Photometer	:	A photometer for comparing two light radiation wavelength by wavelength.
Spherometer	:	For accurate measurement of small thickness, or curvature of spherical surfaces..
Tensimeter	:	For measuring vapour pressures.
Tensiometer	:	An apparatus for measuring the (1) surface tension of a liquid .(2) moisture content of soil or (3) tension in a wire, fibre or beam.
Thermo barograph	:	For measuring and recording atmospheric temperature and pressure, consisting of a thermograph and barograph.
Thermocouple	:	For measurement of temperature.
Thermograph	:	A self-registering thermometer to record temperature variations during a period of time on a graph.
Thermometer	:	For measurement of temperature viz. mercury thermometer, gas thermometer, pyrometer, resistance thermometer, thermocouple, Beckman thermometer, thermometer clinical,, thermometer-maximum and minimum.
Thermopile	:	For detecting and measuring heat radiation.
Thermostat	:	For maintaining a constant temperature by the use of a device that cuts of the supply of heat when the required temperature is exceeded and automatically restores the supply when the temperature falls below that required.
Viscometer	:	For the measurement of viscosity.

12.2 Specific Instruments

Some special instruments available are as follows:



Gas/Fume/Vapour Detector & Alarm (Gas Leakage Warning Instrument) : This is an electronic instrument having a sensor and audible alarm to give warning when pre-set air-gas (toxic or explosive) mixture exceeds the set TLV or LEL/UEL limit. It detects flue gases, LPG, smoke, petrol vapours, paraffin fumes, hydrocarbons, ammonia, freon, hexane, acetone, benzene, chloroform fumes, CO, HS, methane, solvent vapours and many poisonous/explosive gases. Various types of gas detector hand models are also available.

Metal Detector : It detects the metallic objects of ferrous and non-ferrous materials hidden in the pocket/bag etc. and can locate the concealed conducts or cables etc., from a close distance. It is like torch and has piezo alarm.

Electronic Flasher : A built-in solid state electronic flasher which can flash mains bulb or series lamps on mains at adjustable flashing rate. It can be used as danger indicator or attracting attention etc.

Electronic Aircleaner : For indoor use up to an area of 25 sq. meters for pollution free clean atmosphere and wherever bad odour is a problem. It also deactivates dust particles suspended in air, reduces effects of secondary smoking and controls virus and retards growth of bacteria.

Alcohol detecting instruments : With electronic alarm to warn before drivers sit behind the wheels or workers on the machines, thus prevent them from alcohol consumption when they are on duty.

Similar other instruments : Explosimeter, Clap switch, LPG level alarm. Gas level indicator. Smoke detector. Insect killer. Proximity switches. Remote controls. Breath analyser, CO/methane detector. Touch switch. Electronic siren. Loud hailer cum siren, Multipoint gas detection (alarm) system, NH, detector, C1, detector. Flammable gas detector. Digital in/out indicator. Burglar alarm. Heat sensor. Manual fire alarm switch. Control cum power unit. Static charge detector. Hand-dryer, Timer, Hooter, 2 wire ionisation smoke detector. Heat detector for locations subject to rapid temperature fluctuations, Halon-1301 fire extinguishing system, CO_2 extinguishing system, Dragger tubes and air pump for contaminated air sampling (different tubes for different gases). Gas chromatography. Solid state potentiometric recorders, Combustion gas detector. Explosive gas detector with personal monitor. Infra-red gas analyser for the measurement of CO, CO_2, CH_3 and other constituents in theppm and percentage range. Dragger polymeter to determine mean value of gas concentrations in air over a period of several hours by means of special gas detector tubes e.g. for CO, NH_3, benzene, vinyl chloride etc. Oxygen detection system for O_2 measurement with audible alarm and fail-safe monitoring. Tunnel control laser. Portable anemometer giving direct reading of wind velocity, Velometers, Noise dosimeter. Noise meters. Calibrators and filters. Temperature data logger, Dust sampler for taking dust samples for gravimetric, chemical and mineralogical analysis, Hilgers i.e. oil and water remover, 1ST (International Sensor Technology of USA) sensor to measure CO, NO_x, NH_3 SO_2, H_2 hydrocarbons, vinyl chloride, acrylonitrile etc., in ppm or percentage level. High pressure liquid chromatography for degassing of solvents not necessary. Refractive index detector. Fluorescence detector. Autosampler, Microprocessor based system controller. Flame arresters (or flame traps) to ensure safety from explosions due to flammable gases, vapours or dusts etc.

Flameproof equipment : Switch gears, lighting fitting, cable/conductor, cable glands, and accessories viz. switch socket, limit switches, rotary cam operated switches or isolators, fuse unit with HRC fuse links, bell, tubelight fixture, glass lighting fitting, flood light, control gear box, bulkhead fittings, handlamp, vessel lamp, safety torch, indicating lamp, ammeter, circuit breaker, distribution board, control station, remote control panels, junction boxes-round and square, flameproof and explosion proof electric motors of type 'd', type ‘e’ (increased safety), type 'n' (non-sparking)" and type 'p' (pressurised) are to be selected for use in hazardous areas. Various Indian Standards viz.: 5571, 8240 etc., are also prescribed.

See Part 1.6.5 of Chapter-24 and Part 8 of Chapter25 for environment monitoring equipment.

12.3 Process Control Instruments

For temperatures : Thermocouples, radiation pyrometers, optical pyrometers, resistance thermometer, all glass thermometers, electronic potentiometer, multipoint potentiometer, automatic electronic balanced bridge, ratio meter, automatic miliameters, liquid type manometric temperature measuring instrument and direct acting temperature controller.

For pressure : Strain gauges, pressure transducers, pressure gauge, vacuum gauge, compound pressure and vacuum gauge, pressure (head) gauge, draft gauge, compound pressure and draft gauge, automatic pressure regulator, viz. gas pressure regulator, fuel oil pressure regulator, direct acting recorders, diaphragm type breathing valve.

High vacuum measurement : Bodurn gauge, Bellos gauge, diaphragm gauge, Mcleod gauge, Knudsen gauge, thermal conductivity gauge, rotating viscometer gauge, heat filament ionisation gauge, Philips cold cathode ionisation gauge.

For level : Liquid level detector, viz. float gauges, mercury manometers, aneroid manometer, liquid level measuring instrument, remote liquid level indicator with continuous type, fixed point indicating device, fluidised solid level detector.

For flow : Liquid filled manometer, float type manometer, head flow meter, belt type meter, wet balance type meter, Bellos meter, force balance meter, integrators, area flow meter, e.g. general, rotameters, piston type area meter, positive displacement meter, weirs, mass and magnetic flow meter, densito-meter, turbine velocity meter, volumetric flow meter, gasoline flow meter, gas flow controller, air flow controller, differential pressure gauges for measuring flow rates.

Quality analysers : Commercial automatic analysers installed on process plant, chromatography apparatus, photoelectric colorimetric gas analyser, gas/ vapour monitor alarm devices and viscoci meter.

For centralised control computers : Digital computers, automatic petroleum processing control system, automatic air operated centralised monitoring and control system, electronic instrumentation system.

Revolution meters : Tachometer, governor, air velocity meter, accelerometer.

Density and specific gravity meters : Psychrometer, hygrometers, dew point meters, viscometer, velocity measuring device, consistency measuring device, densitometer.

See Part 1.6.5 of Chapter 24 for Air Sampling Instruments.

12.4 Process and Control System Characteristics

Chemical processes and operations need efficient process and control system and a variety of instruments for them. Instrumentation and Control (IC) has developed as a special branch of engineering. Exclusive IC department and IC engineers are employed for this specific purpose. Types of instruments - manual, mechanical, pneumatic, hydraulic, electrical, electronic and computer aided, their quality and sophistication are day by day improving. Their design, erection and maintenance certainly need qualified and experienced personnel. When the safety, productivity and control systems are governed by such instrumentation, it occupies due importance and place in modern industry.

Process control system can be classified machine, reactor or parameterwise such as printing or painting machine control, turbine or compressor control, reactor or vessel control; pressure, temperature or flow control, speed control and instrument control. It can also be classified as manual control, autocontrol, semi-auto . control, analogue control and computer control. Classification also exists as mechanical control, pneumatic (air) control, hydraulic (water or oil) control, electronic control etc.

Main functions (objectives) of control system are to collect information, to measure and display it, to control normal working and to detect fault and correct it. The control system depends on process characteristics. Therefore they are discussed first.

Process Characteristics, as mentioned by P.P. Lees, include many things as under :

1. Process characteristics which tend to make feedback control more difficult are measurement problem, dead time, recycle, very short or long time constants, nonlinearity, limit cycles, strong interactions, high sensitivity, high penalties and changes in parameters or constraint.
2. The process disturbances include quality and availability of raw materials, product, services, plant equipment and environmental conditions. These disturbances may be due to malfunction of plant equipment or control system, process materials behaviour, drifting and decaying factors and links with other plants.
3. Function wise they require monitoring, optimisation, scheduling, process investigation, plant commissioning, feed forward control etc.
4. Sequential control characteristics include batch or continuous operation, plant start-up or shutdown, changes in equipment, product quality or throughput, and mechanical handling operations.

Control System Characteristics include manual, analogue and computer control.

Manual control system includes instruments for whole range of chemical and physical properties and a wide range of displays such as panel board displays, computer graphics and displays of flow, current measurement, alarms, sequential control, maloperation, command etc.

Analogue control equipment are used for measurement, information reduction and sequential control. They include data loggers, alarm scanners and trip systems. Trips may be used for safety shutdown function also.

Computer controls include direct digital control (DDC), programmable logic control (PLC), distribution control system (DCS) and supervisory control.

Present trend in control systems is to increase degree of automation and a change in operator's role from control to monitoring.

12.5 Instrument System for Safety

Use of instrumentation for safety is equally important. Process parameters are well known because of the fixed objectives and therefore instrument system for process control developed first. Instrument system for safety developed at a later stage based on learning from accidents and thinking of remedial measures.

Types of instrument systems for safety include fail-safe design, trips, alarms, interlocks; gas, smoke and fire detectors, toxic detectors, reaction runaway detectors, logic systems like PLC, DCS etc.

Some basic principles for safety instrumentation are as under :

1. Instead of providing elaborate or complex instrument system, the hazard should be reduced
2. HAZOP study should be conducted to asses' potential hazards, operating difficulties and instrumentation necessary.
3. The measurement should be of direct variable and at direct location.
4. While designing alarms/other factors like instrument failure, operator confidence, his information load etc. should also be considered.
5. As far as possible instrument design should be fail-safe.
6. Range of the instrument should be sufficient so that even low input can be measured.
7. Control system should be capable of dealing with normal and abnormal conditions e.g. start-up and shutdown.
8. In case of failure of auto-controls, manual controls should also be provided for safety.
9. Fault finding instrument should not be disturbed by the fault itself.
10. Service instruments (e.g. for air, power, inert gas) should have high integrity.
11. Instrument should be checked regularly and repaired quickly.
12. Instrument design should be such that it should indicate its fault easily. The process operator should be trained to find such fault as a part of his duty.
13. Test should correspond as nearly as possible to the expected plant conditions. It may pass a workshop test, but may not perform satisfactorily on the plant.
14. Valves may stick or jam. Jamming in the open position is dangerous. More positive isolation may require double block and bleed valves.
15. Human errors should be fully considered. Ergonomic principles should be applied to reduce human error as far as possible.

12.6 Safety Aspects of Instruments

Instruments failure can also cause accidents. Therefore while designing and manufacturing, it is necessary to consider safety features of instruments also. For examples, ordinary glass or plastic parts may not withstand high pressure or temperature, corrosive metal parts are not suitable for corrosive chemicals, teflon coating with stainless steel is required for material like oleum, lead is preferred to make film badges for shielding against ionising radiation, electrical parts must conform to Indian Standard for better performance and special alloys are required for special purposes. F.P. Lees has listed following features:

1. Instrument may fail due to a functional fault or loss of containment from the instrument.
2. Slight glasses or rotameters, made of glass, can break and leak. If leaks are dangerous, glass should be avoided.
3. Material of construction should be proper. After considering the properties of the material to be handled and working parameters, material for instrument should be selected.
4. Pressure transmitters and regulators can be damaged by overpressure. If they break, their pressure should be safely released.
5. Protection against corrosive fluid is necessary, e.g. use of inert liquid in impulse lines on pressure transmitters or of chemical diaphragm seals on pressure gauges.
6. Sampling and impulse lines should be checked for blockage. Steam tracing is useful against freezing (e.g. Phthalic anhydride).
7. A thermowell to hold thermometer should be carefully designed to take into account corrosion/ erosion effect.
8. Pulsating flow in flowmeters can cause inaccuracies. Design of orifice plate should consider this factor.

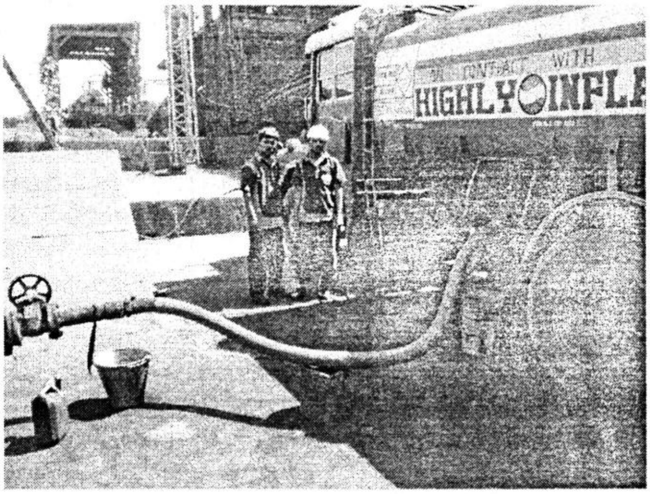
9. Complex instruments like analysers, speed controllers, vibration monitors and solids weighers are generally less reliable. Consequences of their failure should be carefully analysed.
10. Out of different types of pressure regulators (e.g. PRV, NRV, EFV, SV,RD), the right one should be selected at right place. No bypass should be provided between pressure regulators.
11. A control valve should be selected properly. Nominal capacity, range ability, control characteristics, flow limit when fully open, cooling fins for temperature protection, bellows seals to prevent leaks and mechanical balancing (capacity) against process pressure are the factors to be considered for selection.
12. Instruments should not become a source of ignition. Electrical area classification should be considered. They should be flameproof as per requirement.

13 SAFE TRANSFER OF CHEMICALS

Chemicals are transfer by pipelines and also by different types of containers. Their Safety aspects are stated below.

13.1 Pipeline Transfer :

See Part 3.2 (Rules 87 to 101) of Chapter-28 for transportation of petroleum through pipelines.



Pipelines are required to carry a variety of materials such as water, steam, air, oil, gas (inert or toxic, vapour or compressed), brine, solvent and other liquid and gaseous chemicals. From storage tanks to process vessels, from process vessels to product tanks and from there to filling (loading) points, pipelines are required. They may be above ground, underground or as per requirement. Some 20 to 30% costing is estimated in pipelines and their fittings like flanges, valves, gauges, nipples, glands, bends, elbows, plugs, reducers, joints, couplings, ferules, vents, drains etc. Pipework may be of cast iron, mild steel, stainless steel, lead, copper, plastic i.e. PVC, PP, HDPE, rubber, canvas, glass, FRP, glasslined, rubber lined, teflon coated, asbestos cement, RCC, stone, ceramic etc. '

(1) Criteria for Piping Installation :

Main factors are - material of construction, design and layout, supports and clamps, welding or flange joints, packing and gaskets, valves and other fittings, easy approach and working platform and testing and maintenance.

Material of construction is selected depending on nature (corrosivity, toxicity, flammability etc.), quantity (weight, flow, pressure) and other parameters like temperature, viscosity, colour, expansion etc. Thickness of pipe, its quality, welding pattern, flanging are to be considered while selecting for high pressure and temperature. For extremely hazardous chemicals, pipes are tested for inter granular corrosion and certified before used. Insulation is applied .to preserve heat and tracing (contact tubing) for supplying heat to the inner material.

Various Codes like Indian Standards (hundreds of Indian Standards are prescribed for variety of pipes, their fittings, couplings, threads, colour-code etc., see BIS Handbook), ASME (American Code), British Standards (e.g. BS 1710, 1319, 537, 4159). and International Standards ISO R 508 for colours for pipes for inland installations and on board ship. Indian Boiler Regulations also provide details for pipe selection, design, fabrication and testing for boiler purposes.

(2) Safety Aspects of Pipe work :

Generally probability of leakage from pipelines is proportional to the length of pipelines, number of joints, valves, vents, bleeds, drains etc. and complexity such as number of pump connections, recycle streams, hours of working, etc. Therefore it is advisable to

1. Minimise pipe length, branches and joints, and flanges on vacuum lines.
2. Provide welding joints for highly flammable or toxic chemical, good gaskets and gland packing, flange guard to deflect leak downward, flexibility to allow thermal expansion, bellows subjected to axial movement, drains and traps at visible places, removable plugs on sample points, adequate pipe supports, walkways, platforms or working place, proper slopping for draining, overhead clearance for vehicle movement (about 6 m), ergonomic design for valves to be operated and gauges to be seen, earthing and bonding to remove static charge due to flow, overflow return from measuring vessel to a storage tanks, painting with colour coding (IS:2379) and cathodic protection where required.

More pipework in dyke is not desirable, particularly with hazardous chemical, as it may be trapped in fire in the dyke. Similarly pipelines of flammable or toxic chemical should not be laid in tunnel, as its leak may spread from one area to another. Electric cables or hot lines and flammable gas or liquid lines should not run side by side. Solvent line should not be laid below the corrosive line. Seam joints of rubber lined pipes should be kept upward.

Piping arrangement should be such that in case of failure at any point, the system can be quickly isolated by closing valves, without disturbing the rest of the system. Flushing arrangement should be provided for easy start up and maintenance. Pipe alleys should not run over the walking alleys, normal layout should be near the walls or in sides. To allow for thermal expansion special joints or loops should be provided.

Emergency control valves should be easily accessible. By-pass valves should be within easy reach. Autocontrol valve should have bypass or manual valve which may be required in the event of failure of autocontrol valve. Particularly at the outlet of bulk storage of hazardous chemicals, manual and remotely controlled auto isolation valve both should be provided as near as possible to the outlet. Pressure relief device, liquid seal, manual vent valve etc. should be provided to depressurise the system where necessary.

Many different types of valve exist. It is essential to choose the type best suited for the particular operation it has to perform. For instance, if ball valves are to be fitted in a high pressure position, they should be trunnion mounted. Where positive segregation of products is required, say at a multi-product manifold, it is essential to provide block and bleed valves for continuous monitoring of valve seats and seals. For positive isolation some form of soft .seat with a wedge gate action is desirable.

Pumps must be designed not only to suit the immediate pipeline requirements, but should take into account future developments. Thus, it may be necessary to stipulate a pump casing pressure much higher than the pump can generate, if series or boosting pumping is envisaged. Care should be taken to ensure that additional or larger impellers can be fitted as the system demand grows. The maximum operating pressure for the pump mechanical seals should match the pump capabilities. It may be necessary to provide product filtration to protect the minimum clearance of the pump moving parts, particularly on modern high efficiency pumps.

Flexible pipes, joints and hoses should be safe, sound and properly tested. Bolted clips are preferred to jubilee clips. Proper supports or hangers are necessary.

Glass piping, equipment or gauge needs external protection to protect against external impact or internal bursting and flying fragments coming out.

Layout drawings of piping and fittings should be maintained and corrected when any changes are incorporated.

Use of plastic piping is increasing. When it is used for hazardous gas like hydrogen, LPG, chlorine etc., utmost care is required to ensure safe joint. Normally metal compression fittings (rings and nuts) are used. Softer ring is preferred over hard compression ring. Nut should not be loosened. It should be frequently checked for leakage. When any leakage is noticed, first the supply cylinder valve should be closed instead of operating any electric switch or spark generating device.

Semi-conductive material for hoses preferred over non-conductive or good conductive material to avoid static electricity. The conductance should be between in 10^{-4} to 10^{-8} mho.

Failure of packing in valves, stems or flange gaskets, opening the wrong valve or failure to depressurise the system before opening the joint and un insulated steam or hot lines can cause accidents. Remedial measures are splash guard, replacement of gasket, tagging and work permit procedure, colour coding and proper training and supervision.

In above ground pipe work which remains isolated during normal operations, thermal relief system should be provided to protect against increasing ambient temperature.

(3) Underground Pipelines:

Petroleum products, crude oil, and natural gases are some of the more important products transported by underground pipelines. The size may vary anywhere up to 50" diameter and pressure up to 1200 psi. Pipelines are laid for long distances, often across national boundaries. Booster stations are largely automatic stations requiring very fail-safe devices. The pipelines are usually buried about 1 meter underground and must be protected against corrosion. Leakage are likely -to occur. The pipelines have to be checked constantly. The biggest danger to pipeline come from outside sources like unauthorised digging and from corrosion.

Pipelines should be given special additional protection at various points along the route as road and river crossings. Generally, they may be placed at a greater depth beneath rivers and ditches to allow for dredging or ditch deepening. Concrete protection slabs may be placed above the pipe to warn anyone who may excavate in the area. If the ground is particularly stony or rock filled, sand may be imported to cover the pipeline or a special protective wrap may be used.

During construction of a pipeline, all welds are visually examined. Generally, a percentage are radio graphed to ensure that there is no cracking or undue slag intrusion and that there is suitable fusion between the weld and the parent metal. The pipeline is wrapped to protect it against corrosion once it is buried. The wrapping is normally tested by a 15,000 volt pressure test to ensure there are no holes in it. Additionally, an impressed current cathodic protection system is superimposed to protect against subsequent wrapping damage due to stones, roots, etc.

Pipeline control systems should be capable of recognising and measuring leak conditions and initiating the appropriate action to shut down the system and minimise the amount of product leaked.

(4) Colour Code for Pipelines :

Requirement for Indian Standard 2379 is given in Table 18.8.

Table 18.8 : Identification of Pipelines

	Service	Ground colour	1st band	2nd band
1	Cooling water	Sea Green	French blue	-
2	Boiler feed water	``	Gulf red	-
3	Condensate	``	Light Brown	-
4	Hot water	``	Light grey	-
5	Drinking water	``	French blue	Signal red
6	Treated water	``	Light orange	-
7	Cold water	``	French blue	Canary yellow
8	Untreated water	``	White	-
9	Compressed air	Sky blue	-	-
10	Vacuum	``	Black	-
11	Steam	Aluminium IS : 2339	-	-
12	Diesel	Light brown	Brilliant green	-
13	Lubricating oil	``	Light grey	-
14	Drainage	Black	-	-
15	Ammonia Cl2, HCl, SO_2	Canary yellow	Dark violet	-
16	Acids	Dark violet	Different colour for different acids	
17	Brine	Black	White	
18	Caustic solution	Smoke grey	Light orange	
19	CS_2	Black	Light orange	
20	Air	Sky blue	White	Black
21	O_2	Canary yellow	White	
22	CO_2	``	Light grey	
23	Ethylene	``	Dark yellow	Signal red
24	Ethylene oxide	``	``	Brilliant green
25	N_2	``	Black	

Colour code is also given for many other materials. For colour shade see IS 217, 166, 410, 537, 101, 309, 628, 221, 631 and 437. See also Part 7.3.2 of Chapter 9 for colour coding.

Identification of pipelines is necessary to avoid any mistake while operating any valve, taking connection or opening the line for repair c maintenance. For outside servicemen it is most useful.

Colour bands are superimposed on the ground colour. Minimum width of colour band is 25 mn Width ratio of first band to second band should be 4:1 Size of lettering should be as under :

Outer Dia of Pipe Covering (mm)	Letter size (mm)
20 to 30	10
30 to 50	20
50 to 80	30
80 to 150	40 etc.

Where flow direction is to be indicated, arrows or letters are painted near valves, junctions etc. and at suitable intervals along the pipe.

(5) Precautions in Breaking Pipelines :

Following precautions are necessary while opening or breaking any pipeline :

1. Prepare work permit. Tag the joint or portion to be broken.
2. Close or lock the isolation valves to stop flow in the line to be opened. Isolate the area.
3. Stop pump and motor. Remove fuse so that motor cannot be started.
4. Drain, vent and cool the line completely. See that the pressure is zero and the pipe is cool.
5. Wear PPE like hand gloves, face shield, apron, respirator etc. depending on chemical . Keep fire extinguishers ready.
6. Support the line on both the sides of joint. If it can fall, hold it by a lifting machine. Flange nuts and bolts should be opened slowly. A temporary flange guard should be put so as to protect from splashes or dripping. First the farthest nut-bolt should be loosened so that splash if any, may not come toward the body. Dripping, if any, should be allowed fully. Then the adjacent nut bolts should be opened. To separate flanges, a metal wedge may be used if necessary. Final bolt will be opened only after completion of dripping. Spark should be avoided.
7. After removing choking by scrapping, digging or drilling, the removed section of the line, valve etc. should be decontaminated by water, air or purging inert gas. If this is not possible, it should be tagged with warning, indicating the contaminant.
8. Use stable platform. Working by sitting on other pipelines, ladder or structure is risky.
9. Safety shower, running water hose, fire extinguisher, absorbent etc. should be kept ready for. use.
10. More precautions should be taken while opening dead lines or pipes whose content is not known.
11. Direct cutting by hacksaw or gas flame without knowing the content is hazardous. Flammable, corrosive or toxic content must always be removed first.

13.2 In-Plant Transfer :

From storage at production place, chemicals are transferred or transported to an user place or another storage place. It. may be from one place to another outside place or within the factory premises.

Chemicals are transferred in solid, liquid or gaseous forms. Solids are transferred in lumps or powder form and may generate dust, for which dust compression or extraction system is necessary.

Liquids are transferred by gravity, pumping or by water, air or inert gas pressure. Splashes from vessels, pipes, joints, pumps, glands, valves and cracks are possible. Control • of flow rate, safety showers, absorbents and personal protective equipment become necessary. Gases can leak through cylinders, valves, pipes, joints, vessels, gauges etc. Flow rate control, scrubber, condenser, venting and safe discharge are essential.

(1) **Through pipelines :** Most plants have a system of storage tanks for liquids or even materials which can be easily melted. The liquids are pumped to measuring tanks from where they are charged to the reactors.

Safe practice is to pump to the measuring tank and an overflow line returning to the tank.

The pipelines can be of various materials, depending upon the nature of chemicals handled-steel, stainless steel, polythene, polypropylene, PVC, glass, lead, glass lined, rubber lined. The pipelines should be well laid, giving adequate support, provision for maintenance, and painted for correct identification, as per IS : 2379. Pipelines carrying LPG and flammable material should be properly bonded and earthed Isolation valves should be provided for easy control in case of breakage and maintenance.

(2) **Drums :** While handing liquids from drums, the material can be emptied by sucking into a measuring vessel or by pumping out, using a small pump that could go into the bung opening; or by a gear pump. Air pressure should not be used, more so with toxic or corrosive liquids. Transfer by vacuum and using necessary PPE is the best procedure.

Solids can be discharged into reactors by drum titters or emptied onto specially designed screw conveyor. Cut drums should not be invariably used. They can cause plenty of accidents, as workers are not careful to hammer down the sharp edges. Partially used drums must be covered, special protection should be taken to preserve the chemical and the product identified.

Empty drums are not really empty, if they have been used for solvents unless specially cleaned.

Dangerous chemicals like dimethyl sulphate, benzoyl chloride, etc. require elaborate cleaning to really wash out the traces of harmful ingredients.

(3) **Naked carboys and glass bottles** should never be transported. They should be transported in wooden crates or cases, properly closed and handled to avoid damage to the container.

(4) **Plastic Carboys** are very easy to handle and sturdy. Special spouts are usually provided to prevent spillage.

(5) **Conveyor belts** are frequently employed for handling large quantities of chemicals. When dealing with organic powders, steps should be taken to see that static charge is not generated.

(6) **Pneumatic conveyors** are increasingly used for transportation from one place to another within the plant.

(7) **Gas cylinders** should be handled with the right type of tackle, trolley and certainly not thrown down. They should be protected against the heat and impact. When kept vertical, they should be clamped or tied to prevent fall. See Part 8.4 also.

14 SAFE TRANSPORTATION OF CHEMICALS

Transportation is by road, rail, water or air. Containers are mostly standardised to ensure safety during transit. When a truck or tanker meets with accidents or leaks on the way, ft creates problem. Fire or explosion can cause harm to public or property. Corrosive or toxic chemical can cause harm to public, animals, birds and environment. Sometimes grave emergency is created. Warning to public, speedy rescue operation, evacuation and calling helping hands may become necessary.

While considering transportation of chemicals one has to consider the physical and chemical properties of the product being handled, whether it is a solid, a powder, a liquid or a gas under pressure; the type of packing, hazards, and the mode of transport available.

See Part 6.2 of Chapter-28 for Statutory Provisions for transport of hazardous goods

Before transfer or transportation of chemicals, their modes of packaging should be considered.

14.1 Modes of Packaging

(1) Glass bottles and carboys are some of the oldest packaging available for corrosive liquids, solvents etc. Some of the bulk industrial materials still being transported in bottles are Bromine, Mercury etc. The laboratory reagents and pure grade chemicals are also transported in glass bottles of various sizes. Many corrosive chemicals like Nitric acid, Sulphurylchloride, Thionylchloride etc., are transported in glass carboys holding 25-50 kg of the material. These glass bottles and carboys have to be properly protected against shocks. Wooden crates for carboys, plastic or paper packing for bottles is usual. Dangerous chemicals are further protected by packing in clay or other absorbent material so that in case the bottle breaks, the chemical is absorbed and causes least damage.

Flame Retardant Chemical Resistant

(2) Plastic bottles, jars, carboys and drums : These could be constructed out of polythene either of low density or high density, PVC or other materials. Quite a lot of chemicals ranging from laboratory chemicals to industrial raw material are being packed and transported in plastic containers. These containers may be further protected by wooden cases. The material must be correctly chosen. Several tragedies have occurred because, on long storage the plastic containers became brittle and the chemical leaked out.

(3) Steel drums in various sizes have been used for storage and transportation of solvents and chemicals. Even corrosive chemicals like chlorosulphonic acid are shipped in steel containers. This is quite a common packing for chemicals of all description; and quite economical too. Recently polythene and PVC liners, as well as polythene lined drums, have been made available and these are used for packing even highly corrosive materials like hydrochloric acid. Proper sealing of the drums is essential.

(4) Bags of various types: Jute bags and paper bags are used for the innocuous chemicals like Soda ash, Salt, Kieselguhr, etc. Polythene lined jute bags have been used for the materials which need to be protected against moisture. Woven high density polythene bags are being used for packing corrosive and water sensitive materials like Caustic Soda and. Caustic Potash. Obviously this packing cannot stand piercing and must be well protected and handled such that the bags are not damaged. In transport, the bags must be properly stacked and secured.

(5) Gases under pressure in cylinders : Quite a few gases like Chlorine, Sulphur dioxide. Ammonia, Ethylene oxide. Oxygen etc., are sold in cylinders containing quantities ranging from 50-100 KGs. Steel cylinders are the commonest, but various kinds if linings are also given for special products. The rules governing the design, testing and filling of cylinders are quite elaborate and must be followed.

(6) Tank cars for bulk transport of chemicals are very common, particularly for petroleum products, solvents, acids and alkali solutions. Tanks can be made of various materials of construction such as steel, stainless steel, rubber lined FRP or FRP lined, lead-lined or any other special construction. The tank cars could be in various sizes, holding 5-10 tons for road transport or 20-50 tons or more for rail transport. Now a days long tankers/trailers have been used to carry more weight.

The tank cars should be properly designed and fabricated to meet the service condition. Contamination should be avoided, as it could be dangerous for the product as well as the tanker. Good arrangement for receiving the chemical as well as discharging should be provided. Vent valves and arrangements to prevent static electricity build up when handling solvent, are a must. Gases under pressure such as liquefied natural gas, chlorine, etc. are also transported by tank cars. Then FFE and PPE should be carried with the vehicle and their safety rules should be followed.

14.2 Transportation by Different Mode:

Some safety aspects of transportation by different modes are as under :

(1) Railroad Transportation:

It accounts for quite a large proportion of the chemicals transportation. The greatest hazard in this mode of transportation is that because of the far flung operations, it is not possible to train everyone connected with the operation in the proper care to be taken. Proper labelling of hazards involved is a help. Derailment and accidents are other hazards.

The preventive measures are : (a) improved design of the tankers and the couplers, (b) limitations on the size of the tanks, (c) positioning of the hazardous chemicals away from the locomotive (d) avoiding hunching together of hazardous chemicals (e) proper labelling of content and the hazardous nature of the chemicals.

A serious risk is that an accident may occur at a place which is not easily accessible and where competent guidance may not be available. In the USA Dan organisation (CHEMETREC) has been set up to deal with such cases.

(2) Transportation of Explosives by Rail :

Such rules (Railway Red Tariff Rules 62 to 74) are as under :

1. No explosives other than safety fuses and fireworks shall be transported by rail except in the van specially constructed for the carriage of explosives and approved by the Chief Controller of Explosives and the Railway Board.

2. Label 'Explosive' on each side of the carriage shall be affixed.

3. Carriage containing explosives shall be kept away from the engine (other than electric locomotive) and close coupled to the adjoining carriage not loaded with explosives or other flammable or hazardous substances

4. Not more than 10 carriages containing explosives shall be attached to any one train. Not more than 5 carriages of explosives shall be loaded oi unloaded at any one time at any railway station.

5. No explosive shall be transported by any passenger or mixed train.

6. Safety fuses for blasting, explosives of the third class (nitro compounds) in the form of cartridges and not exceeding 2.5 kg in weight, detonators upto 200 (each weighing upto 225 gms) and sporting powders and propellants in double packing as prescribed, can be transported by passenger or mixed trains.

7. Explosive consignment shall be received at the specified railway premises only, during sunrise and sunset and by an authorised railway servant only.

8. Shunting of carriages containing explosives shall be carried out under the supervision of authorised officer. Shunting speed shall not exceed 8 km/hi and no loose shunting will take place.

9. The packages shall be removed by the consignee within 12 hours of day light following their arrival. The Station Master shall keep the packages at a safe distance and covered with tarpaulins or other suitable material.

10. No explosive shall be carried except by rail across any railway bridge. This rule is not applicable to carry safety fuses or gunpowder or nitro compound upto 5 kg or ammunition Class-6, Division 2 and 3.

International Regulations concerning carriage of dangerous goods by rail (RID) and British Railways list of dangerous goods and conditions of acceptances also provide rail transport guidelines.

See also Part 7.2.1 (5 to 8).

(3) Road Transportation:

Road tankers are constructed in a wide variety of materials like steel, stainless steel, lined material and FRP construction. Sometimes they need to be heated or cooled.

Road tankers and their fastenings should be capable of absorbing following forces -

1. In the direction of travel-twice the total weight.
2. Vertically downwards-twice the total weight.
3. Vertically upwards-total weight.
4. Horizontally at right angles to direction of travel-total weight.

The service equipment such as valves, fittings, gauges etc. should be protected against impact. Three types of independent stop valves - internal, external and blind flange- are required. For certain gases like HF, shell opening at bottom is not permitted. Fusible plug to operate below 93 °C is suggested in case of petroleum tanker. Spark arrester on exhaust, a portable fire extinguisher, TREMCARD emergency kit and instructions to driver are also necessary.

See Part 6.2 of Chapter-28 for Central Motor Vehicles Rules, 1989 for transport of hazardous goods also. Display of class labels on goods package (e.g. box, drum) and carriage (e.g. vehicle, truck, tanker) are compulsory u/r 129 and 134 respectively.

(4) UN, DOT, ADR, or SOLAS-74 Classification

The hazardous chemicals/dangerous goods are divided by the United Nation Committee of Experts on the Transport of dangerous goods into the following classes :

CLASS 1	:	Explosives
Division 1	-	Substances and articles which have a mass explosion hazard.
Division 2	-	Substances and articles which have a projection hazards but not a mass explosion hazards.
Division 3	-	Substances and articles which have a fire hazard and either a minor blast hazard or a major projection hazard or both, but not a mass explosion hazard.
Division 4	-	Substances and articles which present no significant hazard.
Division 5	-	Very insensitive substances which have a mass explosion hazard.
CLASS 2	:	Gases compressed, liquefied, dissolved under pressure or deeply refrigerated.
CLASS 3	:	Inflammable liquids.
CLASS 4	:	Inflammable solids, substances liable to spontaneous combustion; substances which, on contact with water, emit inflammable gases.
Division 4.1	-	Inflammable solids.
Division 4.2	-	Substances liable to spontaneous combustion.
Division 4.3	-	Substances which on contact with water, emit inflammable gases.
CLASS 5	:	Oxidising substances; organic peroxides.
Division 5.1	-	Oxidising substances.
Division 5.2	-	Organic peroxides.
CLASS 6	:	Poisonous (toxic) and Infectious substances.
Division 6.1	-	Poisonous (toxic) substances.
Division 6.2	-	Infectious substances.
CLASS 7	:	Radioactive substance.
CLASS 8	:	Corrosives.
CLASS 9	:	Miscellaneous dangerous substance.

See IS:1446 for classification of dangerous goods.

Arrangement for loading and unloading of the liquid have to be well designed. It is preferred to load toxic and flammable material from the bottom. It is preferable to provide a discharge pump on the tank.

Drums, crates and cylinders are also transported by trucks. The-important thing to see is that the chemical is securely packed so that spillage do not occur on the road and the toxic vapours are not released. The cylinders or drums should be securely lashed so that they do not fall off the truck and cause danger. The driver and the attendant should be fully conversant with the nature of the material and the hazards involved; and trained to handle the situation.

See also Part 7.2.1 (5 to 8).

(5) Emergency Planning for Transport of Hazardous Chemicals:

Various directives and recommended actions have been issued by international organisations like UN Committee of experts on the transport of dangerous goods, European Economic Committee (EEC), US Department of Transport etc. They need special labels or notices on packages or on vehicles, display of correct technical name of the chemical, special signs or plates, instruction in writing to the drivers i.e. TREMCARD (Transport Emergency Card), safe packing conditions, particulars in transport documents, display of supplier's name, address and phone number including phone number from where specialist advice can be available.

Master tests of some 400 TREMCARDs of hazardous substances are readily available from Chemical Industries Association of UK. ICMA of our country should also provide such cards in Indian languages.

The content of a 'Trerncard' should include name of cargo (material), nature of its hazard, protective devices including PPE and emergency action to (1) inform Police and Fire Brigade (2) Spill or gas control (3) Fire control and (4) First aid.

The transporter should carry 'Emergency kit' containing tool kit, emergency lighting, fire extinguisher, protective clothing, breathing equipment and first-aid kit

Proper training to drivers of hazardous chemicals is legally required. Safety checklist or transport vehicles shall be prepared and used. Tramcard should be given to workers. See checklist 2 of Part 15.3. See Chapter 31 for road and traffic safety.

Emergency Action:

In case of toxic release :

1. Driver of hazardous cargo should be trained to handle small emergencies.
2. Inform police, fire brigade and manufacturer.
3. Takeout trerncard, MSDS etc. from vehicle and give it to police.
4. Vehicle should be taken in open area and parked away from thickly populated area.
5. Cordon the area around leak.
6. Stop traffic and keep people away from the vehicle.
7. Leaking liquid can be contained in bunds of sand/earth.
8. Small leaks can be plugged by wooden peg.
9. If a leak is from cylinder valve it can be capped by yoke clamp.
10. A leaking cylinder can be turned so as to bring leaking portion in gas phase.
11. Water is not to be added on leaking cylinder and spill if chemical is corrosive.
12. Use water sprays, fogs to absorb toxic vapour cloud.
13. Evacuate the downwind area in case of large toxic leakage.

In case of inflammable chemicals :
1. Park vehicle on the road side.
2. Stop engine.
3. Inform police, fire brigade and manufacturer.
4. Takeout trerncard, MSDS etc. from vehicle and give it to police.
5. Cordon off the area, stop traffic and keep people away.
6. Do not smoke. Ignition source to be avoided.
7. In case of fire, try to extinguish it with fire extinguisher.
8. Try to stop leak by cutting off the source, close valve.
9. Keep the tank cool by water sprays to avoid explosion.
10. Surrounding area should be checked for explosion possibility and evacuated if necessary.

For Threshold Quantities of handling (including transport/transfer) chemicals and applicability of Public Liability Insurance Act and Rules see part 10 of Chapter 29.

(6) Water Transport :

Quite a lot of chemicals are transported by ocean going ships and on river tugs. Crude oil petroleum products, natural gas and other dangerous goods are some of the biggest bulk commodities in international commerce. Because of their huge quantities involved, spillage and leakage can create gigantic pollution problems, besides a fire hazard. There have been several mishaps of this type. Tanker design has assumed special safeguards being made to prevent accidental spillage.

When solid chemicals are transported, care should be taken that the material will not cake up because of moisture, so that it may require to be emptied pneumatically. When carrying drums or cylinders they should be properly lashed so as not to break loose. In river transport, spillage of chemicals may cause very serious pollution problems.

The carriage of dangerous goods by sea is day by day increasing. About 4000 million tonnes cargo enters world seaborne trade every year, of which about 100 million tonnes are dangerous goods in packaged form. More than 1 lac types of hazardous chemicals are transported by sea. They include solid, liquid and gases in bulk. While cutting oil-tanks and pipelines on ships at Alang shipyard (Bhavnagar) many fatal accidents have taken place. Thus these are the end problems even after transportation by sea.

International maritime Organisation (IMO), International Convention for the Safety Of Life At Sea, 1974 (SOLAS 74) and International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL 73) have developed guidelines and codes for carriage of dangerous goods in packaged form by sea.

IMO has formulated International Maritime Dangerous Goods (IMDG) Code and 'Emergency Procedures for Ships carrying dangerous goods (EmS)'.

SOLAS has formulated 'Code of safe Practice for the Shipment of Bulk Cargoes (BC Code)' for transportation of dangerous solid goods in bulk.

Medical First Aid Guide (MFAG) for use in accidents involving dangerous goods, is available in IMO/WHO/ILO publication. IMO/ILO guidelines for packing cargo in Freight Containers or Vehicles and IMO recommendations on safe use of pesticides in Ships are also available.

SOLAS have classified dangerous goods in 9 classes [see UN Classification stated in foregoing para].

Main information required are proper shipping name and UN No., chemical name, formula, properties and observations, classification, packing, labelling, stowage and segregation, angle of repose, MFAG table number and special emergency procedure and action to be taken.

Training courses for ship's officers and crew are also recommended.

15 INSPECTION, TESTING AND MAINTENANCE

15.1 Process Flowchart and its Importance for Inspection

Process flow chart is most important in a chemical factory. It is to be designed by plant in-charge or process supervisor as per company's requirement. It includes names and weights of raw materials to be charged, their sequence of charging, time cycle for heating, cooling etc. and addition of water and other reactants. Reaction time details are to be filled in by shift in-charge, chemist or supervisor. After reaction is over, as the batch or process proceeds, those operations are also to be added. Sometimes it is called batch sheet when flow chart is prepared batch wise.

Process flow chart is useful in carrying out inspection. It helps us to take round in a chronological order of the process flow and to understand the process systematically. During inspection, round is required starting from unloading of material to the storage facility, process buildings/unit operations, filling of products, product godown, loading of product and effluent treatment plant etc. If process flow chart is understood in advance, inspection can become easy and complete.

15.2 Inspection Techniques for Plants, Vessels and Procedures

For plant safety inspection see Part 2 of Chapter 19. Those types of inspection and general guidelines are also useful for inspection of hazardous installations. Some specific techniques are mentioned below:

Detailed guidelines were issued on inspection of MAH installations under ILO Project IND/86/MOI/ FRG and circulated by the CLI, Bombay in January 1991. It was also reproduced in some different form in 'Training Manual (TM8)' on 'Labour Inspection and its Role in Improving Safety and Health with particular reference to the Chemical Industry' at Bangkok in June 1987. Its short abstract is given below :

Main areas of inspection are tabulated as under-

Inspection Areas

- Standard Conditions of Process & Storage
  - 1 Initial information
  - 2 Process description
  - 3 Operating instructions
- Plant Integrity
  - 1 Safe working limits
  - 2 Design, construction, inspection, test and certification
  - 3 Protective devices
  - 4 Maintenance
  - 5 Inspection & testing
  - 6 Inspection authority
  - 7 Evaluation of plant integrity
    - A Vessels
    - B Pipelines
    - C Pumps & ancillary equipment
    - D Modification to plant & equipment
    - E Management control
- Process Deviations
  - 1 Variables
  - 2 Process chemistry
  - 3 Pressure
  - 4 Temperature
  - 5 Level
  - 6 Flow rate
  - 7 Impact
  - 8 Services
  - 9 Start-up & shutdown
  - 10 Operator's error
    - A Sensory failure
    - B Failure in logic
    - C Failure to act properly
- Emergency Procedure
- Fire Precautions

Some salient points on above areas are summarised below:

1. Serious incidents arise from loss of containment of hazardous substances. Therefore these possibilities and plant items should be inspected in details.

2. The most vulnerable parts of die plant, procedure or system should be identified from going through the plant layout, process flow diagram and walking round the installation. Records of failure history and past accidents are useful.

3. Safety arrangements should be checked also in relation to off-site impact with the local population.

4. All available expertise should be applied, e.g. engineering, chemical, medical, management etc. A meeting and discussion with the experts in the plant can be useful.

5. Competency of the occupier and contractors should be verified regarding better choice of process, catalyst, equipment etc., operating pressure, temperature, residence time etc., and management control systems.

6. Process documents like process description, operating procedures, safety information, emergency manual etc. should be scrutinised for completeness and quality.

7. Process description should be inclusive of principles involved, basic chemistry of main and side reactions, hazards of materials and safety precautions, plant, equipment list and line diagram, transport, storage and transfer arrangements, operating parameters and their safe limits, SOPs and procedure for authorising process changes.

8. Operating instructions should include flow sequence & batch sheet, conditions to be maintained, actions of process controls and monitoring instruments, allowable variation limits and action necessary when that limit is reached, emergency procedure, reporting route and training schedule of operators.

9. For 'plant integrity, safe working limits of plant (including pressure vessels) should be carefully established as design data and compatible with normal process operating conditions.

10. The design data should include the range of pressure, temperature, loading, flow rates, operation cycles, basis for pressure relief and properties of substances.

11. The plant should be designed, constructed, inspected, tested and certified according to the design and construction code which will achieve the safe working limits.

12. Protective devices may include pressure/ vacuum relief valves, rupture discs, explosion vents, high/ low level alarms, high/low temperature/pressure alarms, weight tables, content gauges, maximum fill devices, padding air/gas reducing valves and many forms of instrumentation. Such devices should be checked for its suitability for the purpose intended.

13. Safe systems of work may include manual venting procedures, loading/unloading systems and temperature control at fill. Cold content stored below their safe temperature may cause brittle failure.

14. A scheme of testing protective devices should be made by a competent person with due regard to local conditions (e.g. environment), consequences of failure, duplication, fail safe provision and risk physical damage.

15. Preventive and conditions-based maintenance schemes should be established.

16. The plant should be periodically and appropriately inspected and tested. The vessel should be reassessed for continued use with particular contents and the safe working limits confirmed or revised. Pressure limits should be revised if the thickness is found reduced. Certification should specify safe working pressure, vacuum, temperature, load and fill ratio where the content may expand with temperature rise and date of next examination.

17. Pressure vessels should be inspected as per statutory requirements. The date of next inspection should be certified by the competent person.

18. Pipelines, pumps and ancillary equipment should also be periodically inspected and maintained. Colour code should be followed. Where failure can be hazardous, standby equipment should be provided (e.g. diesel driven fire pump, scrubber pump, stand-by power generator etc.). Emergency procedure should be available in case of pump or equipment failure.

19. Modifications to plant and equipment should be of a standard of original integrity, otherwise the plant should be down-rated. The modification should be tested and certified by a competent person for use and ability.

20. All process deviations which may affect the plant in relation to loss of containment should be scrutinised and the occupier's competence to prevent losses should be technically appraised. Such deviations concern process chemistry, pressure, temperature, flow rate, liquid level, viscosity, surface tension, pH, moisture content, contaminants, presence or absence of air/oxygen/ inert gas etc., impacts by external forces like vehicles, falling bodies etc., utility services, startup and shutdown abnormalities and operators' errors such as sensory failure, failure in logic (judgement or decision) and failure to act properly (omission) or acting improperly (commission).

Training can do little to anticipate these errors but good process design can minimise their effect and ensure that no single mistake will be capable of causing catastrophe. Effective supervision, check-lists and work permit system can reduce the incidence of errors.

Causes of pressure rise are failure of pressure protection or regulating system, temperature rise, exothermic, run-away or polymerisation reaction, back feeding of reaction mass into storage vessel etc. It can result in fire, explosion or/and toxic release.

Causes of temperature rise are failure of heat control, failure of cooling system, fire, exothermic reaction etc. It may result in rise of pressure, flow rate, filling ratio, foaming of vessel content, rollover, irreversible metallurgical change to vessel. It needs immediate venting or dumping.

Causes of level rise are failure of overfill prevention device, overflow device, level control device, communication between operators, misrouting of process streams, siphoning, loss of vacuum/pressure, surging etc. It may result in overflow, spillage or vessel rupture.

Causes of flow rate deviations (too high, too low or reversed) are changes in differential pressure, failure or furring up of pumps, pipelines and ancillaries, loss of pump prime, vapour lock, operator's error etc. It may result in pressure/ temperature deviations, rupture of process, heater or heat-exchanger, erosion or cavitation within pipes and pumps.

Criteria of investigation include sizing and location of pipes, pumps, vents, flares etc., isolation valves, gravity discharge, flexible connections etc.

Thus types of process deviations are many and so are their effects. Inspection process or checklist should pay due attention on them.

21. Emergency procedures include physical controls, systems of work and emergency plans (e.g. onsite/off-site emergency plan). Operators should be trained for emergency shutdown action when and how to be followed and when to consult senior officials. Procedures for quick stopping the reaction, dumping or flaring and by-passing the content should be established.

To control or mitigate effects of heavy spillage, measures like bunding, extra tank, catchments pits, dump vessels, diversion walls, grading of the ground and use of absorbents or super-sucker etc. are required. Bund walls should withstand thermal shock, hydrostatic loading and corrosivity of the chemical. For highly liquefied flammable gases like LPG, a remote evaporation area and sloppy floor are required. For toxic or cryogenic liquids, surface area should be minimised to reduce th6 evaporation, or suitable blanketing material should be sprayed. Possible adiabatic flashing may also be considered.

Effects of explosion can be reduced by impact walls near chances of explosion. Integrity of control room should be ascertained. Storage quantity and length and size of pipework should be minimised. Vessel outlets and fixed pipework should have remotely operated isolation valves.

Necessary personal protective equipment conforming to Indian Standards should be given to workers and well maintained. Workers should be trained to use them.

22. Fire protection for process and storage should be sufficient. Space separation, water drench, insulation, fire walls, adequacy of the fire water storage; their pumps and equipment, portable

extinguishers, fixed fire control installations, hoses, staff and regular fire-drills etc. should be vprifipd

CHECKLISTS:

Many checklists are available and can be developed for inspection of factories. Some sample checklists are given below :

15.3 Checklists for Routine Inspection of a Chemical Factory

(1) Checklist-1

Name & Address of the Factory :
Inspected on Date : Time :
Inspected by
Names of some workers contacted : (1) (2) (3)

A. Structural Stability and Safety :

1. Parts of building/shed requiring repairs.
2. Parts of vessels/ machinery requiring repairs.
3. Parts of Stairs/platforms requiring repairs.
4. Parts of storage/overhead tanks requiring repairs.
5. Parts of pit, sump, gutter, cover requiring, repairs.
6. Others requiring repairs:
7. Lightening arrester required? provided ?
8. New extension / alteration.
9. Stability Certificate available ?
10. Specific remarks, if any (Viz. Doors open outward ? etc.) :

B. Solvent Liquid chemical Storage Tanks :

<table>
<tr><td>1</td><td>Sr. No.</td><td>Chemical</td><td>No. of Tanks</td><td>Capacity</td><td>Fittings</td></tr>
<tr><td></td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td colspan="2">Vents with flame arrester</td><td>12</td><td colspan="2">FEE</td></tr>
<tr><td>3</td><td colspan="2">Flare connection</td><td>13</td><td colspan="2">PPE</td></tr>
<tr><td>4</td><td colspan="2">Automatic level indicator and high level alarm</td><td>14</td><td colspan="2">Fencing/gate/lock provided?</td></tr>
<tr><td>5</td><td colspan="2">Absorption media connection with drain safe valve</td><td>15</td><td colspan="2">Lightening arrester necessary? Provoded?</td></tr>
<tr><td>6</td><td colspan="2">Flame /smoke detector with alarm</td><td>16</td><td colspan="2">For acid/alkali/and other substances, safety showers near?</td></tr>
<tr><td>7</td><td colspan="2">Toxic/Combustible explosive gas detector with alarm</td><td>17</td><td colspan="2">From tanks how the chemical sent to the plant ?</td></tr>
<tr><td>8</td><td colspan="2">Earthing</td><td>18</td><td colspan="2">Is measuring tank provided ?</td></tr>
<tr><td>9</td><td colspan="2">Bund wall/ dike / sump</td><td>19</td><td colspan="2">Flameproof fitting necessary ? Provided ?</td></tr>
<tr><td>10</td><td colspan="2">Notice</td><td>20</td><td colspan="2">Permission of Explosive Dept. obtained ?</td></tr>
<tr><td>11</td><td colspan="2">Remote control device for emergency drain and water spraying</td><td></td><td colspan="2"></td></tr>
</table>

C. Gas Cylinders Storage :

1	Name & No. of Cylinders usually stored ?		
	O_2 (black)	CO_2 (black & white)	Acetylene (maroon)
	N_2 (grey)	NH_3 (black, red & yellow)	LPG C_4H_{10} (red_)
	Cl_2 (yellow)	Freon CCl_2F_2 (grey & violet)	Argon A (blue)
	Air (grey)	(Colour Code IS : 4379)	
2	Is the storage separate, away from source of heat and cordoned ?		
3	Gas detector with alarm.		
4	FFE & PPE nearby ?		
5	Are the cylinders safely arranged ?		
6	Notice of operating / handling instructions.		

D. Chemicals Store/ Godowns :

1	Combustible chemicals separate ?
2	Reactive (oxidizing, reducing, compatible, dissolving, flammable, explosive, corrosive, etc.) chemicals separate ?
3	Inorganic & Organic, liquid (drums, carboys etc.) separate ?
4	Poisonous chemicals in a locked room ?
5	Flameproof fitting necessary ? Provided ?
6	Earthing, FFE & PPE, Cautionary notice provided ?
7	All doors and windows can be locked properly ?
8	Ventilators as per vapour density provided ?
9	For acid / alkali, safety shower near ?
10	Quantity of each raw material and each product stored at any time.

E. Pressure Reactions:

1. Name and No. of Pressure Vessels and reactiol (Process, Steam, air etc.):

	Name of Vessel / Reaction & Location	Working Temperature Pressure	Exothermic ?	Then Constant cooling system provided ?
1				
2				

2. Safety Valve
3. Pressure gauge
4. Temp. gauge .
5. Second Safety valve necessary? (above 100 psi) Provided ?
6. Steam pressure reducing valve necessary? Provided ?
7. Rupture disc necessary? Provided ?
8. Drowning tank necessary? (after S.V. / R.D.) Provided ?
9. Scrubber necessary? Provided ?
10. Stirrer stop-alarm necessary? Provided ?
11. Flame-proof motors / fitting necessary? Provided ?
12. Earthing necessary? Provided ?
13. Temperature cut off device necessary? Provided ?
14. Feed/charge control necessary? Provided ?
15. Quenching device for neutralisation necessary? Provided ?
16. Drain / Discharge pipe?

17. Manhole
18. Vessel structure, foundation, position safe?
19. Pressure Test Report available? Date of last testing
20. Surrounding space open?
21. Sources of ignition near? Safety measures
22. Platforms, stairs, fencing, guarding provided?
23. Documents of complete reaction, reaction rates, pressure/temp, rise, exothermocity etc. available?
24. Gas/Flame detector in vicinity required? Provided ?
25. If jacketed (limpet coil) vessels, fitting with the jacket and how is the heating / cooling system?
26. Other devices necessary (viz. pressure temperature recorder, auto controls, alarms, remote controls etc.) Provided ?

E. Distillation Process:

1. Name and No. of Vessels, Process etc.

Sr. No.	Name of Vessel	Chemical	Atmospheric or Vacuum?	Column Provided?	Condenser Provided ? Heat/ Feed cut off device with condenser ?	Receiver Unit		
						Vented	Scrubber necessary?	Provided ?
1	2	3	4	5	6	7	8	9
1.								
2.								

2. Nature and type of heat source (direct heat, heat through jacket, heating media etc.)
3. Heat control devices provided?
4. Temperature gauge
5. Pressure/Vacuum gauge
6. Drain Pipe
7. Manhole
8. Stirrer necessary?
9. Source of spark away?
10. Flameproof motors, fitting necessary?
11. Platform, stairs, railing, guarding provided?
12. Gas/Flame detector in vicinity required? Provided? 13. Others necessary and provided?

G. Other Processes:

Sr. No.	Name of Vessel or equipment	Name of Process	Operating Temperature Pressure	Chemicals used / reacted etc.	Dangerous Conditions	Safety Devices Provided	Measures Still necessary
	1	2	3	4	5	6	7
1							
2							

H. Toxic and Explosive Gases, Fumes, Dust etc. and Controls :

Sr. No.	Name of the gas, fume, dust – evolution & probability	Toxic, combustion able or explosive	Its location	Scrubber and its type	Other neutralizing device (water blanketing etc.)	Flare, Incinerator	Gas Detector with alarm	Other controls necessary
1	2	3	4	5	6	7	8	9
1								
2								

Sr. No.	Gas Detection		Devices to collect safe discharge	Wind direction and velocity indicator available ?	Refrigeration unit for temp. control, N_2 or brine barrier etc.	Others
	Measuring instrument available	Periodic testing record available				
1	10	11	12	13	14	15
1.						
2.						

I. Liquid Effluents:

Sr. No.	Effluent	Nature, (acidic poisonous, fuming, corrosive etc.)	Discharge system (open gutter etc.)	Treatment Plant			Pumps, Motors, Machine guarding	Platform, Stair, Pond, Sump, Fencing etc.
				Provided ?	Approved by Pollution Board ?	Records maintained ?		
1	2	3	4	5	6	7	8	9
1								
2								

J. Flameproof, Explosion proof & Dustproof Fittings ?

Sr. No.	Place where such fitting is necessary	Type : Flame / Explosion / Dust proof motors, starters, switches, wiring etc.	Is it provided ?
1	2	3	4
1			
2			

K. Water Facility :

1	Water showers at 2.1m height with 2.5 cm dia pipe provided / Where not provided/ Water blanketing necessary ?	Provided ?
2	Eye washers/ Bottle / Wash basins/ Taps	Provided ?
3	Bathrooms provided ?	
4	Cooling water in jackets, condenser etc. available for all hours ? Own overhead water tank available ? If not, what is the alternate arrangement ?	
5	D.G. Set or Diesel engines ready to run water pumps when electricity fails ?	

6	Drinking water facility available ? Needs more centres ? Needs improvement ?	

I. Emergency Action Plan, Safety Manual, Workers' Training etc. :

1	Planned for operating emergency? (small fire, air failure, power failure, cooling water failure, steam failure, gas leakage, and storm etc.)
2	Planned for fire emergency ?
3	Planned for Disaster emergency ? (Explosion, flood, tank rupture, earthquake, riot/strike etc.)
4	Is safety manual ready and given to all concerned ?
5	Area all workers trained for these emergency operations ?

M. Medical Check-up of workers and records :

1	Pre-employment medical check-up ? Record available ? First-aid available ?
2	Place of work as per above report ?
3	Periodical medical check-up : At what interval? Forms maintained?
4	Cases of occupational disease/poisoning detected & recorded? Reported to Authority?
5	Name and address of the nearest Doctor/Hospital available?
6	ESIC facility available for such occupational health check-up and treatment?

N. Good Housekeeping :

1	Where cleanliness required ?
2	Lifting machinery safe moving ?
3	Tools etc. in safe position ?
4	Safety posters, precautionary notices in all rooms, floor displayed ? Where more necessary ?
5	Motors, gears, pulleys, belts, chains, coupling etc. guarded ? What not guarded ?
6	Stairs, platforms, railing covers etc. guarded/ Where required ?
7	Ventilation (natural and mechanical) and lighting adequate ? Where need more ?
8	Lunch room, canteen, clock-room, lockers, ambulance room, first-aid necessary ? Provided ?
9	Are labels provided on all chemicals stored and manufactured ?
10	Others : (Processes of fire and explosion hazards in separate room etc.)

O. Personal Protective Equipment (PPE) :

1	Hazards to be faced
2	Types given
3	Types necessary : Chemical filter, mechanical filter, air-line respirator, suction hose mask, pressure hose mask, canister gas mask, helmet, face shield, safety goggle and type, leg guard and type, apron and type, full suit, safety belt, others.

P. Fire Fighting Equipment (FFE)

1	Hazards to be faced
2	Types provided
3	Types necessary : Water type (Soda Acid), water type (gas pressure). Foam type, CO_2, type. Dry powder type. Hand & Stirrup pumps, water bucket, sand bucket, fire drills. No smoking notices. Flame traps Auto sprinklers. Hydrants, Fire calling buttons on all floors or in each room.

Q. Statutory Safety Records :

1	Form No. 9 (Hoist & Lifts)	7	Form No. 29 (Accident Register)
2	Form No. 10 (Lifting Machinery)	8	Safety Policy necessary ? Provided ?
3	Form No. 11 (Pressure Vessel)	9	Safety Committee necessary ? Formed ?
4	Form No. 20 (Health Register)	10	Safety Officer necessary ? Employed ?
5	Form No. 21 (Accident Register)	11	Records of safety meetings, accident investigation available ?
6	Form No. 22 (Poisoning/ Disease)	12	Compliance of safety inspections available ?

See also Reference No. 12 at the end of this Chapter for a further checklist of ten tables.

(2) Checklist-2

(A) Checkpoints before allowing a transport vehicle into factory gate.

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
1	Qualified and licensed driver. No intoxication.		
2	Name & quantity of material as per order & bill. Note vehicle No.		
3	Quality of material arrived i.e. sampling.		
4	Trem card.		
5	Tyre condition, spare wheel and jack.		
6	Main valve & other fittings, in safe condition.		
7	Blind disc, gasket etc.		
8	Piping, couplings and tools.		
9	Tanker pressure test certificate if required		
10	Last material filled in and contamination if any.		
11	Cleanliness of the tank, if it is for filling.		
12	Exhaust muffler (spark arrester), if required.		
13	Fire extinguisher.		
14	Personal Protective Equipment required.		
15	First Aid Box and Antidote.		
16	Taking away bidi, cigarette, match box etc., and no smoking instruction.		
17	Product license, if any.		
18	Static charge and leakage, if any.		
19	Compatibility of the material to be transferred,		
20	Others as per social need.		

(B) Checkpoints before unloading hazardous material into storage.

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
(a)	**Liquid chemicals:**		
1	Fixation of vehicle - wheel stopper, barricade, gear locking, engine stopping and wind direction		

	consideration. Note vehicle No.		
2	Level checking of factory tank and road tanker and material matching.		
3	Proper piping connections.		
4	Safe flexible hose pipe & couplings.		
5	Emergency transfer preparedness.		
6	Earthing. Flameproof electrical motors and fittings if required.		
7	Deep feed pipe to avoid static charge.		
8	Proper vent condition.		
9	Vapour line safety.		
10	Purging connection.		
11	Neutralising material for spillage.		
12	First Aid Box and Antidote.		
13	Fire Fighting Equipment.		
14	Personal Protective Equipment worn.		
15	Emergency kit ready.		
16	Lifting machinery, if required.		
17	Pump checking. Coupling guard, if required.		
18	Avoidance of air pressure transfer. If it is required, pressure gauge and safety valve on air tank. Pressure testing of air tank.		
19	Dyke, dyke discharge valve and partition wall condition. Acid proof lining for corrosive material,		
20	Safety shower / eye washer.		
21	Tank level gauge working and safe overflow pipe.		
22	Tank vent. Breather valve, N_2 purging, flame arrester. Pressure gauge. Safety valve. Non-return valve. Excess flow valve, Lightening arrester etc. as per need.		
23	High/low level alarms and trips. Indication of flammable condition inside the tank.		
24	Operator on duty during full unloading.		
25	No smoking and no tempering.		
26	Record filling.		
27	Spillage washing.		
28	Engine restarting only after closure of tank and tanker valves, and spillage cleaning.		
29	Special precautions depending on nature of chemical viz. Flammable, toxic, corrosive, explosive etc.		
30	AC godown for liquids of low boiling points.		
(b)	**Gases / Gas cylinders :**		
1	For liquefied gas in tanker viz. LPG, EO, NH_3, points as B(a) above.		
2	Double checking of earthing .and flameproof electrical connections.		
3	In case of leakage, portable hood and scrubber device, discharge in safe media, safe venting in air etc.		
4	Personal Protective Equipment.		
5	Fire Fighting Equipment in ready condition.		
6	For gas cylinders, lifting and transfer device.		
7	Open space for speedy dispersion of leaking gas.		

8	Wind sock in vision and consideration of wind direction.		
(c)	**Solid materials and godown safety :**		
1	Godown/warehouse condition regarding good ventilation, lighting, cooling, flooring etc. Windows/ Grills/ Louvers at I m height.		
2	No electric fitting for highly flammable material. Sufficient natural lighting.		
3	Flameproof electric fitting for flammable material.		
4	Separate stacking of flammable & toxic material - Zone or Area classification.		
5	Use of wooden/plastic crates and shelves.		
6	Spill collection arrangement and safe disposal to ETP or incinerator.		
7	Surrounding rain water gutters.		
8	Waste collection, beg filling and safe disposal. Ready stock of neutralizing material.		
9	Safe disposal of empty containers.		
10	Compatibility of material, before putting together.		
11	Proper flooring-slope, pit, pump etc.		
12	Water line for cleaning,		
13	Air line for use of air line respirators,		
14	Proper tools, trolleys, lifts and containers for safe and easy transfer.		
15	Smoke/Flame detectors and gas leak detectors with alarms.		
16	Sprinklers and other fire fighting equipment inside and outside the rooms.		
17	Personal Protective Equipment required.		
18	Locked godown for poisonous material.		
19	Fire resistant walls/doors if required.		
20	Emergency exit on opposite side.		

(C) Checkpoints for Process Plant and Equipment.

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
1.	Selection of proper material of construction for a new vessel/reactor, and modification.		
2.	Proper design and fitting of vessel/reactor as per standard codes. Small batch size desirable.		
3.	Operating conditions at less pressure, temperature, flow, slow reaction rate and less hazards desirable.		
4.	Condition monitoring and pressure testing of vessels and equipment.		
5.	Safety fittings like Pressure gauge. Temperature gauge. Rupture disc. Level indicator, Non return valve. Excess flow valve, interlocks, alarm and trips. Flameproof fitting where required.		
6.	Safe operating procedure and safe close down procedure displayed for operator.		
7.	Batch sheet design and full filling with details.		

8.	Fire fighting equipment.		
9.	Use of personal protective equipment.		
10.	Open space, maintenance space and leakage checking.		
11.	Scrubber connections and scrubber working.		
12.	Safe columns, condensers, receivers and vent chillers and safety valve for distillation process.		
13.	Auto and manual devices to stop heating, charging etc., and quenching or safe transfer of material in case of emergency.		
14.	Close transfer/charging of hazardous material.		
15.	Local exhaust ventilation on toxic material charging, transfer and filling/packing,		
16.	Double earthing and static charge eliminator where required viz. Solvent in a glasslined vessel.		
17.	Proper piping and colour code.		
18.	Checking of proper O_2/N_2 lines and cylinders to avoid accident.		
19.	Use of safety work permit.		
20.	Machine guarding for drives, pumps etc.		

(D) Checkpoints for Pollution Control

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
(a)	**Effluent Treatment Plant (ETP)**		
1	NOC and consent from GPCB.		
2	Norms suggested by GPCB like pH, BOD, COD, Oil & grease, colour, odour, suspended solid, total dissolved solid, heavy metals etc. Fill the format of logbook given below.		
3	Norms prescribed under the Factories Act (Schedule-2). Fill the format.		
4	Drawing approval of ETP.		
5	Continuous operation of ETP.		
6	Primary and secondary treatment plants.		
7	Continuous monitoring of parameters for final discharge from factory premises.		
8	Whether pollutant being discharged above prescribed limit?		
(b)	**Gas Emission/Leak Control**		
1	NOC and consent from GPCB.		
2	List of emission/leaking points, pollutants and their prescribed limits. See the format.		
3	Selection of proper scrubbing media.		
4	Proper design and continuous working of scrubbers/flare/ incinerator etc.		
5	Final vent gas detector with alarm and discharge value.		
6	Whether pollutant being discharged above prescribed		

	limit?		
(c)	Solid Waste Disposal.		
1	Authorisation from GPCB.		
2	Waste quantity and planning of safe transport and discharge.		
3	Waste classification.		
4	Incineration or method of safe disposal for detoxification of waste		
5	Safe burying in a land approved by the Govt.		
6	Safe disposal of waste and toxic containers.		

Format of Logbook for Pollution Control

Sr. No.	Name of Pollutant	Prescribed value (Norm)	Measured Value	Date & time of measurement	Difference of columns 3 & 4 and remedial measures required	Implementation of remarks in column – 6
1	**2**	**3**	**4**	**5**	**6**	**7**
1						
2						
3						
4						
5						
6						

(E) Checkpoints before allowing finished product to go out from factory gate

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
1	Quality as per assurance and quality certificate.		
2	Marking and labelling of name, weight, batch, hazard class etc. on packages.		
3	Proper containers and safe weight within limit.		
4	Safety instructions.		
5	TERM CARDS/MSDS.		
6	Safe vehicle - proper truck/tanker body and valve, gasket, blind disc., vent, gauges, tyre condition, spare wheel, qualified and trained driver with cleaner, tools, First-Aid box. Antidote, pump and flexible piping and phone numbers.		
7	Necessary papers and licenses.		

(F) Other check points.

Sr. No.	Points	Yes/ No.	Suggestion or Remarks
1	Qualified & Experienced supervisor in each shift.		
2	Training to all workers.		

3	Safety policy and its copies to workers.		
4	Pocket safety manual given to workers.		
5	Safety committee and record of its meeting and working.		
6	Onsite Emergency Plan and its rehearsal.		
7	Medical check-up of workers.		
8	Safety Officer required? appointed?		
9	Safety poster, signs, symbols etc., displayed?		
10	Safety work permit system for all hazardous works.		

15.4 Pressure Vessels and their Safety Aspects :

Pressure vessels are of two types : (1) Fired Pressure Vessels which include Boilers, Economisers, Steam Pipes, Fittings etc., as per section 2, 2A, 2D of the Indian Boilers Act 1923, and (2) Unfired Pressure Vessels which include reaction vessels, autoclaves, digesters, heat-exchangers, receivers, containers, compressors, vulcanisers, agers, kiers, dyeing vessels, jacketed kettles etc. operating above the atmospheric pressure.

The portable gas cylinders, metal bottles used for storage or transport of compressed gases or liquefied or dissolved gases under pressure, gas-tankers, vessels for nuclear energy, refrigeration plant of less than 3 TPD capacity, vessels operating below I kg/ m2 etc., are not covered under the purview of the pressure vessels.

15.4.1 Pressure System Components and Safety Devices

Pressure system components are :

Pressure vessels	Pressure relief devices
Pumps, Compressors,	Pressure gauges
Fans, Control valves,	Pressure reducing valve (PRV)
Piping system, Tracing	
Dump vessels	Non –return valve (NRV)
Steam traps,	
Insulation	Pressure controllers or regulators
Vent for pressure relief	Utilities like steam, water, air, thermic fluid, inert gas etc.
Pressure recorders	

See Part 8.2 for various types of pressure relief devices. Other components are explained at their respective places.

Pressure reducing valve (PRV) is a statutory requirement u/r 61 of the Gujarat Factories Rules. It is to be provided between a source of supply of pressure (e.g. boiler or higher pressure side of any header) and the user point or a vessel receiving the pressure. It is to be set at a desired safe pressure. It will reduce the pressure on delivery side accordingly. This is the main safety function. A safety valve and a pressure gauge should be provided on low pressure side and a pressure gauge on high pressure side to see the pressure reduction. It shall not be bypassed at any time. It should be tested periodically.

Spring loaded safety valves with oil seals are desirable. For high pressures, rupture or bursting disc or rupture diaphragm should also be provided. Pressure reducing or pressure control valves are necessary. Safety valve should be connected nearest (close) to the vessel. It should not be connected where pulsating pressure fluctuates.

Rupture or bursting disc should be provided in upstream of the safety valve and if toxic or inflammable ' mixture/gas is pressed, ducting should be provided covering fully the outlet of the rupture disc so that in case of rupturing of the disc, the mixture/gas coming out from it will be collected in duct or blow down tank and not in environment.

Rupture disc and safety valve can be provided in series (in vertical line of the same outflow) with a pressure gauge in between. Two such sets can be provided side by side, parallel, on two different outflows, to handle much volume at a time. RD and SV can be provided in parallel also. In any case, their setting should be slight different to allow time lag.

Fusible plugs, pressure gauges, temperature indicator, stop valve, drain valve, air vent, auto controls and recorders are also necessary.

Routine inspection schedules should be devised for maintenance of pressure safety devices in good working order. A sample schedule regarding rupture disc inspection is given below as a guidance.

Routine inspection of rupture discs

Procedure:

1. Obtain Permit to Work Certificate from Plant incharge.
2. Obtain Rupture Disc Inspection Record sheet.
3. Ensure system to be worked on is isolated, free from pressure and vented/drained down.
4. Check that vent line drain hole is clear. Note : If no drain hole exists raise modification work order to make one.
5. Carefully remove rupture disc and holder ensuring no debris enters vessel, and clean thoroughly.
6. Check that all bursting disc specifications are correct.
7. Inspect rupture disc holder for pits, hairline cracks or other damage and renew if necessary. Ensure inspection is carried out using adequate light.
8. Ensure rupture disc inlet and outlet vents are clear and free from obstruction.
9. Check mounting flanges are clean and parallel. Note : The Team Manager must assess the significance of the conditions found and arrange, if necessary, to review the future maintenance periodically.
10. Renew gaskets and refit rupture disc and holder, ensuring disc is correctly orientated.
11. Carefully tighten diagonally opposite bolts to achieve a gas tight seal, using torque wrench if necessary.
12. Ensure plant is safe for use, complete permit to work and hand over to Plant in-charge.

Rupture Disc Inspection Record

Rupture Disc Details	
Equipment No.	
Burst pressure	
M.O.C.	
Type & size	

Examination	
Disc defects	
Contamination	
Blockage	
Disc holder	
Vent pipe	
Comments / Actions	

Checked by : .... Date : ....

(Name & Designation)

Frequency: 2 years.

Courtesy : GLAXO India Ltd., Ankleshwar.

15.4.2 Standards & Codes

Section 31(1) of the Factories Act 1948, Rule 61 of the Gujarat Factories Rules 1963 and Section 1.2.1 of the Indian Standard -Code for Unfired Pressure Vessels IS:2825 give definition of the pressure plant/ vessels. The operating pressure should be above the atmospheric pressure.

The IS:2825 provides more details on the subject of construction and other requirements for the design, fabrication, welding, inspection, testing, marking and certification of fusion welded unfired pressure vessels in ferrous and non-ferrous metals. Terminology of maximum working pressure, design pressure, minimum thickness and allowances to add into it, weld joint efficiency factor, ligament efficiency, post-weld heat treatment and allowable stress value are also explained in this Code. Pressure relief devices and corrosion, erosion and protection details are also given. It has considered BS 1500, 1515, ASME and the Swedish Code.

For ISO 14001, OHSAS 18001 and other Standards see Part 1.17 of Chapter-19.

Rule 61 of The Gujarat Factories Rules :

The terms design pressure, maximum permissible working pressure (MPWP), plant and pressure vessel are defined.

Design Pressure means the maximum pressure that a pressure vessel or plant is designed to withstand safely when operating normally.

Maximum Permissible Working Pressure (MPWP) means the maximum pressure at which a pressure vessel or plant is permitted to be operated or used under this rule and is determined by the technical requirement of the process.

Scope : This rule applies to a pressure vessel or plant operating above the atmospheric pressure and includes piping system.

The rule does not apply to

1. Vessels operating at a pressure below 1 Kg/ cm^2.
2. Where Indian Boilers Act 1923 is applicable.

3. Where Gas Cylinders Rules 1981 are applicable.
4. Where pressure is solely due to static head of liquid.
5. Vessels with nominal water capacity less than 500 litres connected to a water pumping system.
6. Vessels subjected to nuclear energy.
7. Refrigeration Plant of capacity less than 3 tonnes per day.
8. Working cylinders, steam traps, turbine casing, steam separators, dryers, strainers de-superheaters, oil separators, air receivers with MWP below 1.33 Kg/cm2 and volume 85 litres, and other air vessels.

Design & Construction : Every pressure vessel or plant should be

1. Properly designed on sound engineering practice. .
2. Of good construction, sound material, adequate strength and free from patent defects.
3. Properly maintained in a safe condition.

When Indian Standard or any other Code is applicable, a certificate from the manufacturer or competent person shall be obtained and produced before an Inspector.

Safety Devices:

1. Suitable safety valve or pressure relieving device of adequate capacity to ensure that MPWP shall not be exceeded. If more safety valves are provided, one will be set at MPWP and others at not more than 5% in excess of the MPWP.
2. Suitable pressure gauge with dial range 1.5 times the MPWP and red mark indicating MPWP.
3. Stop or isolation valve to shutoff the pressure source.
4. Drain cock (valve) to drain the vessel.
5. Suitable pressure reducing valve (PRV) or automatic pressure regulator to disallow the pressure greater than the MPWP. A safety valve shall be fitted on low pressure side of such device.

15.4.3 Fundamentals of Pressure Vessel Design

IS:2825, Section I includes in its Design section, General Provisions, Corrosion, erosion and protection, Cylindrical and spherical shells. Domed ends. Conical ends. Unstayed flat heads and covers. Stayed and braced plates. Openings branches and compensation, Access and inspection openings. Bolted flange connections. Ligament efficiency, jacketed vessels, Supports and Internal structures.

The Code also explains materials of construction, allowable stress, materials for low temperature service and materials for welding.

It also explains flange calculations for non-standard flanges.

Design, marking, capacity, setting, installation and discharge lines of pressure relieving devices are also specified.

In its Section II manufacture and workmanship are explained in the headings of Approval of design, General considerations and Design of welded joints, Preparation of parent metal. Assembly of plates and fit-up, Alignment and tolerances. Welding procedure, Welding of non-ferrous metals. Rectification of welds, Repair of drilled holes. Repair of cracks and Post weld heat treatment. The Section also prescribes Welding procedure, qualifications and Welder's performance qualifications.

Section III of the Code gives Inspection and Test methods. Marking and Records.

Then Appendices A to N give various values of stress, temperature, recommended practice, typical design of welded connections and proformas.

These are the fundamental subjects of pressure vessel design, construction, inspection and testing. For the details the Code (IS-.2825) itself should be referred. Basic formulae from the Code are given below.

Design Formulae : The following formulae shall apply in the case of cylindrical and spherical vessels subject to internal pressure.

For Cylindrical Shells

$$t = \frac{pDi}{200fj-p} = \frac{pDo}{200fj+p} \quad \text{or } p = \frac{200fjt}{Di + t} = \frac{200fjt}{Do - t}$$

For Spherical Shells

$$t = \frac{pDi}{400fj-p} = \frac{pDo}{400fj+p} \quad \text{or } p = \frac{400fjt}{Di + t} = \frac{400fjt}{Do - t}$$

where

t = Minimum thickness of shell plates exclusive of corrosion allowance in mm

p = design pressure in kg/cm^2

Di= inside diameter of the shell in mm.

Do= outside diameter of the shell in mm.

f = allowable stress value in kg/mm^2 (see Appendix A IS-.2825)

j= Joint factor or efficiency (see Table 1.1 IS-.2825)

Depending upon the material of the shell and the design temperature, the factor 'f' should be selected from the tables given in Appendix A of the IS:2825 This 'f' is from 9.5 to 9.8 for some carbon and low alloy steel plates to be used upto 250°C design temperature.

J = 1.00 to 0.90 for Class I vessels i.e. normally used. J = 0.85 for Class 2 and J = 0.7 to 0.5 for Class 3 vessels.

For example, for a cylindrical shell of 5 kg/cm: design pressure (p), internal diameter 1000 mm (Di) f = 9.6. T = 0.9. the thickness t is given by

$$T = \frac{5x1000}{200 \times 9.6 \times 0.9 - 5} = \frac{5000}{1728-5} = \frac{5000}{1723} = 2.90 \text{ mm}$$

Similarly if thickness and diameter are known pressure can be calculated. For example for the t = 2.5 mm and internal diameter 1000 mm, design pressurep is given by

$$P = \frac{200 \times 9.6 \times 0.9 \times 2.9}{100 + 2.9} = \frac{1728 \times 2.9}{1002.9} = 4.9967 = 5kg/cm^2$$

Thus the formulae are cross-checked.

The safe working pressure (p in lb/in2) of a sizing cylinder shall be calculated on the basis of the minimum thickness actually measured (t in inch), the diameter actually measured (D in inch) by the formula p = 2ts/D where s = stress of the material in Ibs/in2 say 5000 for copper.

For example, for a copper cylinder of t = 1/8 inch and D = 50 inch, safe working pressure will be

$$P = 2 \times \frac{1}{8} \times \frac{5000}{50} = \frac{100}{4} = 25 \text{ psi.}$$

15.4.4 Over-pressure Protection and Pressure Relief Devices :

Pressure exceeding the maximum permissible working pressure (MPWP) of a pressure vessel poses high hazard and needs pressure relief devices.

See Part 8.2 where such devices on storage vessels are discussed.

Rule 61 of the Gujarat Factories Rules (see foregoing Part 15.4.2) requires safety valve or pressure relieving device, suitable pressure gauge, stop or isolation valve to shut off pressure source, drain valve, pressure reducing valve or automatic pressure regulator. In Chapter 28, other safety laws requiring such provisions are also discussed.

IS:2825, Section I, Part 5 gives much details on this subject. It requires as under -

1. Fully liquid filled vessels should have liquid relief valve.
2. If a vessel is fitted with a heating coil or element, pressure increase due to its overheating, should be considered while designing relieving capacity of the protective device.
3. Vessels operating under vacuum should have a vacuum break relief device.
4. Vessels operating under pressure and vacuum (due to cooling of content) both, should have a combined pressure-vacuum relief device.
5. Pilot or other indirect control valve alone are not permitted. Main valve opening at a set pressure automatically must be provided. The relief valve shall be so designed that they cannot be inadvertently loaded beyond the set pressure.
6. Bursting (Rupture) Discs are preferred where pressure rise is fast like explosion, or where choking may make the safety valve inoperative and where even minute leakage of fluid cannot be tolerated (because of high toxicity or flammability). The disc may be mounted independently or in series with a relief valve provided that the bursting pressure of the disc shall not exceed MPWP of the vessel and its opening (diameter) should be sufficient to prevent interference with the proper functioning of the relief valve. If the disc is fitted on the discharge (outlet) side of the valve, back pressure should not be built-up to reduce the lifting pressure of the valve. The disc shall be marked with bursting pressure at a specified temperature and shall burst within ± 5% of that bursting pressure.
7. The relief valve shall be of sufficient capacity to discharge the maximum quantity of the fluid and when it is discharging, pressure in the vessel should not rise of more than 10% above the set pressure.

    The capacity of a relief valve to discharge gas or vapour (other than steam) is given by -

$$W = CKAP\sqrt{\frac{M}{T}}$$

where W = rated capacity in kg/h, C = constant (given in Table 5.1, IS:2825), K = coefficient of discharge depending on shape and specific to any particular valve, A = discharge area in 2 P = accumulation pressure (1.10 x set pressure) in kgf/cm2 abs, M = molecular weight and T = inlet temperature in °K.

8. Set pressure of the pressure relieving device (valve or disc) shall not exceed MPWP. This setting pressure will include the effect of static head and constant backpressure. If more than one protective device is provided, only one be set at MPWP and other devices at pressure not more than 5% in excess of the MPWP.

9. Vapour relief valve shall be provided in vapour space and liquid relief valve in below the liquid level.

10. Discharge line (after relief device) diameter shall not be less than that of the relief device outlet Size of drainage or blowdown tank should be such that it will not reduce the relieving capacity of the relief device. Discharge lines shall be properly anchored, particularly at their open ends, not to allow any displacement.

See Part 8.2, 9.1.5 and 15.4.2 also.

Let us see some practical examples which can cause accidents. Where a pump feeds a receiver, the safety valve should pass the volume being pumped if it has to open. In distillation column where normally there is no pressure, overpressure may be created due to increased heat input because of cooling failure or loss of reflux or loss of sub-cooled feed and increase in temperature difference in reboiler. Therefore safety valve becomes necessary on distillation vessel or column. Low pressure storage tanks can withstand a very low pressure. Safety valve should be provided on it to tackle any accidental pressure rise. Safety valve of low pressure side of a heat exchanger should be sized to handle the flow from twice the cross sectional area of the high pressure tube in the exchanger to relieve its sudden bursting pressure.

To check whether safety valves operate reliably, they should be daily opened by hand.

The number of safety valves on any vessel depends on the volume of working fluid and discharge capacity of the valves.

High noise is created by blowdown of safety valves. Engineering control to reduce this noise are necessary. Workers in safety valves testing area should wear ear, eye and hand protections.

Water Seal is used on pressure vessels that operate at low pressure or slight vacuum such as alcohol stills and gas holders. A U-pipe filled with water with one end connected to the pressure side and other end open works as a low pressure safety valve.

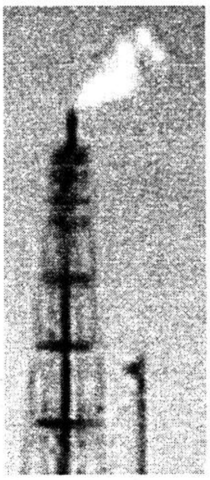
Depressurismg devices or pressure interlocks are required on autoclaves, vulcanisers, digesters, jet dyeing vessels, retorts etc. where charging doors are to be opened. The device or interlock will prevent the door opening till all pressure inside is relieved or prevent the pressure build-up till the door is closed.

High pressure alarms give audio visual alarm that the pressure is being increased. They are useful when pressure relief device may not work. In that event a vent valve or discharge valve should be manually or remotely opened and the reason of non-functioning of the relief device at its set pressure should be investigated.

Pressure/Temperature recorders or printouts are useful to study the process behaviour or investigate an accident happened on the system.

15.4.5 Flare :

In plants where highly toxic or flammable gases are generated in bulk or continuously, a flare, system becomes necessary for their collection and safe discharge by burning at height. The flare should be designed to vent the gases during normal operations and emergency conditions. Maximum possible discharge at a time should be considered for safer venting and preventing pollution of the environment.



A flare system consists of a flare stack and piping to collect the gases to be vented. At the flare tip, steam nozzles are provided for air entrainment and seals to prevent flashback of the flame. At the base a knockout drum is provided to collect the liquid from the gases passing to the flare.

Wet gases and dry, cold gases are collected through separate lines. A low level and a high level flare can be combined together so that normal operating and start-up loads are handled by the low level flare, while both flares are used to handle occasional high volume emergency loads. Thus an environmental impact of flaring can be kept to a minimum.

An intense heat radiation occurs from a flare. Therefore it should have sufficient height and no population in surrounding area. The discharge heat rate may be of the order of 10" BTU/h.

Hazards associated with flaring are -

1. Obstruction in the flare system.
2. Explosion in the flare system.
3. Low temperature embrittlement of the pipework.
4. Emission of toxic materials from the flare.
5. Heat radiation from the flare.
6. Liquid carryover from the flare.

The last three are environmentally objectionable. Smoke, glare and noise of the flare may also cause problems.

Efficient combustion in the flame is necessary otherwise a smoky flame will result. Liquid carryover can also result in smoky flame. By good mixing of fuel gas, steam supply and air entrainment good combustion is achieved. For this, the operator relies on visual observation. An automatic system operates based on flame root temperature.

Because of the air entering down in the stack when the flame may not be working or when any valves are open or due to corrosion this air and flammable gas may enter in explosive range and may explode. To avoid such air explosion, measures taken are purge gas, leak elimination, monitoring oxygen concentration, water seals, molecular seals and flame arresters.

A fuel gas is used as a purge gas to maintain positive pressure in the system to disallow air inside. This can be confirmed (no air intake) by monitoring oxygen content.

Heat radiated from a flare is given by-

$$I = \frac{FQ}{4\Pi r^2}$$

where I = intensity of heat radiation, Q = heat release rate, r = radius from centre of the flame and factor F = 0.16, 0.33. 0.30 and 0.38 for methane, propane, butane and ethylene respectively.

Acceptable heat radiation level at ground level is 1000 'BTU/ t2h so that men can reach in the vicinity of the flare without harm.

If chlorine and sulphur are burned in flares, they will emit HCI and SO_2. This requires more height of the stack so that ground level concentrations of these toxic gases may come down to permissible level.

15.5 Types of Tests, Certificates and Records

Storage and pressure vessels are to be tested and checked for the assessment of their reliability. Testing of pressure vessels and their parts is most essential. Mainly two types of tests are in practice, pressure test and non-destructive tests (NDT). Pressure tests include hydraulic, pneumatic and combined. NDT includes radiography, dye penetrant, magnetic particle and ultrasonic. NDT methods can be used before or after pressure test methods. Mechanical tests are also employed for fusion welded seams and test plates. Main tests methods are explained below.

Tests:

Tanks should be erected after considering its static load (as if fully filled), wind load, factor of safety and other allowances and testing the soil for its bearing capacity and making the foundation accordingly.

The underground tanks should be erected in underground RCC sump so that their leakage cannot pollute the soil or underground water.

The tanks which are not pressure vessels should be tested for its water load (static) test by filling it fully with water and observing any subsidence or damage.

The tanks which are pressure vessels, should be tested as per statutory provisions, its design Code and Standards or recommended by the manufacturer. See Part 9.4.4 following.

Periodicity of fest should be decided after considering material to be filled, its properties, storing parameters (pressure, temperature, flow, vibration etc.), heating/cooling, method of use, rate of corrosion and type and thickness of metal. Its condition monitoring is most essential. See IS:2825 also.

When tanks are tested, its fittings should also be tested and replaced if necessary.

Major causes of material or equipment failure are as under which need to be periodically tested :

1. Suitability (compatibility) of the material of construction (e.g. metal, plastic, lining etc.) with chemical. It can be checked by a metascope. See Table 18.1 & 18.2.
2. Mechanical failure due to excessive stress.
3. Mechanical fatigue and shock.
4. Thermal fatigue and shock.
5. Brittle failure due to cold liquid.
6. Creep due to plastic deformation and rupture.
7. Hydrogen attack due to atomic or molecular hydrogen generated by corrosion. Alloyed steels (with Cr, Mo etc.) are useful to mitigate hydrogen attack.
8. Corrosion by water or corrosive chemicals. See Part 15.6 for details.

Before testing or allowing welding, cutting or repairing, the tanks should be thoroughly cleaned and purged by inert gas if it was containing any flammable material. It should be made gas free if it was containing any toxic or flammable gas. Testing equipment should be safely utilised and a safety work permit should be followed. Oxygen content should also be measured. Top, bottom and side nozzles should be opened and free ventilation should be allowed. First it should be externally examined for manual checks and then it may be hydraulically or pressure tested. Test record should bemaintained.

15.5.1 Pressure Tests :

They are of three types as under -

(1) Hydraulic (Proof Hydrostatic) Test :

Water is used to pressurise the vessel for hydraulic test. By a hand pump, the pressure is gradually increased, stopped, observed any leakage if any and again increased. Test pressure is 1.3 to 1.5 times the design pressure. A standard pressure gauge should be used to watch the pressure. Slight higher test pressure is required for an old or repaired vessel than for a new vessel.

Testing by air, steam or gas pressure is more hazardous as air, steam or gas are more compressible than water and contains more energy at equal pressure. Therefore air-pressurised vessel can burst with great explosive force and can make great damage. The water-pressurised vessel, if bursts at the same pressure, will release less energy, no shock wave will be generated and make less damage. Therefore hydraulic test is a safer test. It provides easy detection of leak also.

After the test pressure is attained, it is held up for some time (15 to 20 minutes). If no leakage or no deformation, the positive test certificate can be issued.

Examinations & Tests u/r 61, Gujarat Factories Rules:

They are prescribed as under -

1. New vessel to be used for the first time Hydraulic test at 1.3 x design pressure.
2. Old vessel, unused vessel for more than 2 months or where repair/alteration is made - Hydraulic Test at 1.5 x MPWP, i.e. maximum permissible working pressure.
3. Where water is not suitable for test - Pneumatic (air) test at
   - Design Pressure for new vessel
   - MPWP for old vessel.
4. Glass lined vessel - Hydraulic or Pneumatic test at
   - Design Pressure for new vessel.
   - MPWP for old vessel.
5. Test certificate from the manufacturer or competent person should be obtained before using any vessel for the first time. Inspector may demand it.
6. No vessel can be operated at a pressure higher than that mentioned in the certificate.
7. Inservice test/examination as under
   (1) External test at 6 months.
   (2) Internal test at 1 year.
   (3) Hydraulic test at 2 years.
   (4) Internal or Hydro test a 4 years for vessel in continuous process.
   (5) If external, internal or hydro test is not possible as above, then - NDT for metal thickness and other defects.

8. Thin - walled vessels of non-ferrous metal
   (1) Maximum life 20 years.
   (2) 5% reduction in MPWP every year.
   (3) New, second hand or repaired vessel shall be tested at 1.5 x MPWP before its use.

Report by a Competent Person :

1. It should be in Form II.
2. Condition stated in report must be fulfilled before using the vessel.
3. Where pressure reduction on repair is suggested, the competent person shall send a copy of such report to the Inspector within 7 days of the completion of the test.

See Part 15.4.2 for remaining part of Rule 61, GFR.

To determine the ultimate bursting pressure, the vessel is subjected to five or more times the design pressure. Burst pressure tests are used only to test a sample of a large number produced to verify the adequacy of calculations and manufacture.

Precautions necessary while hydro-testing are as under

1. Use of standard and correct pressure gauge.
2. Removal of air from the vessel before testing.
3. Visual inspection for clearly visible defects if any
4. Use of a rupture disc to test at a high pressure
5. Protected area away from public. A pit or steelbox is preferable.
6. Limiting the liquid volume in the test vessel to reduce the energy stored at the time of testing. To achieve this, bigger size solid pieces should be inserted in the vessel to take up as much of its volume as possible.

After hydraulic testing if more than 0.2% increase (elongation or deformation) in volume is noticed, the vessel should not be recommended to use as a pressure vessel.

(2) Pneumatic Test:

This test is useful where even traces of water cannot be tolerated in its service or where a vessel is so designed and/or supported that it cannot be safely filled with the water or testing fluid.

Such test shall be carried out under close supervision by the inspecting authority. Adequate precautions like blast wall or pit and means for remote observation are essential.

The pneumatic test pressure should be more than the design pressure but less than the hydraulic test pressure. In the beginning, the pressure should be gradually increased up to 50% of the test pressure. Thereafter it should be increased in steps of 10% of the test pressure till the required test pressure is achieved. Then the pressure will be reduced up to design pressure and held at that pressure for a sufficient time to permit inspection of the vessel.

(3) Combined Hydraulic and Pressure Test :

Here a test vessel is partially filled with water and then air pressure is applied to the space above the liquid level. The test pressure (not exceeding hydraulic test pressure, but more than the design pressure) shall be deducted by the pressure due to the static head of the water in the vessel.

15.5.2 Non Destructive Tests (NDT) :

(1) Significance and Limitations :

Rule 61 of the Gujarat Factories Rules says that if external, internal or hydro test is not possible, NDT in-service test shall be carried out for metal thickness and other defects.

By visual inspection, external or internal, it is impossible to see under surface or inner defects, cracks, porosity, thickness reduction etc. Hydraulic test can check the overall integrity (soundness) of the vessel but it. cannot show the above defects. A way of finding the weakest part by hydraulic bursting, or a test piece cutting is a destructive test. Therefore non-destructive tests are developed to test boilers, pressure vessels and nuclear components.

NDT can detect (1) Inherent metal defects like porosity, shrinkage, non-metallic inclusions (2) Processing defects like residual stresses, cracks caused by grinding of casting and forging, spruing and (3) In-service defects like corrosion, erosion, change in section etc.

Limitations of NDT are : They can measure thickness, cracks, flaws, porosity, discontinuities, soundness etc.. but not the overall integrity of the material against permissible pressure as a proof test. From the measured thickness, permissible pressure can be calculated. Overall integrity of a vessel can be tested by pressure (hydraulic) test only.

(2) Radiography:

IS 2478, 2595 and 2598 should be referred for Code of practice and safety for radiographic testing. IS:2825, Section III, Part 8.7 also explains radiographic examination.

No radiographic examination is required where the thickness of butt welds is less than 6 mm. It is also not required where thickness may be up to 12 mm but the outside diameter is less than 102 mm. For thickness between 12 to 19 mm and diameter between 102 to 170 mm, 5 to 10%- of the total length of welds shall be radiographically examined. For thickness more than .19 mm and diameter more than 170 mm all the welded Joints shall be examined.

Radiography is a process of detecting discontinuities (defects) in test objects by passing ionising (short wavelength) radiation through them and recording the transmitted radiation pattern on X or Gamma ray films.

A simple radiography set-up consists of radiation source (shielded), test object and X-ray film between a pair of lead screens enclosed in a light proof cassette. The image on the film is converted into black or white pattern which indicates the structure of the test object.

An air bubble inside a steel plate shows black spot as more radiation passes through air bubble than the rest of the part and gives more blackening on the film.

A tungsten inclusion in steel plate would appear as white patch compared to rest of the parts as tungsten absorbs more radiation than steel of the same thickness.

Radiographic examination should be conducted before final heat treatment. At least two penetrameters shall be used for each radiograph. A viewing device of suitable illuminating power should be used to see the radiographs on the original films. Each radiograph should be identified with the portion of seam represented. At least 2 % thickness difference should be detected. The width of the radiograph should be at least equal to the total width of the welded joints plus an allowance of about 10 mm on each side of the welded joint.

Where the required quality is not shown by the test, welded joints or parts shall be repaired and reexamined radiographically.

All workers exposed to X or Gamma rays and engaged in radiographic work shall be shielded against direct and scattered radiation.

Follow IS:2598 for Code of safety for industrial radiographic practice.

Nature of personnel exposure is due to external or internal radiation. External radiation arises from radiographic sources, radioactive contamination on inanimate sources and on the skin or clothing of personnel. Internal exposure arises from radio-nuclides within the body. They may enter by inhalation, ingestion through skin wounds or be absorbed through intact skin. Effects of exposure may be somatic and genetic (to descendants) both. Exposure should not be more than the permissible dose.

Personnel monitoring should be done with film badges, pocket dosimeters, pocket ionisation chambers. Workplace monitoring i.e. radiation survey and site monitoring should be carried out by radiation survey instruments - Geiger-Muller tubes and Ion chamber instruments.

External exposure can be prevented or reduced by (1) Reducing time of exposure (2) Increasing working distance from the source of radiation and (3) Interposing attenuating (protective) barriers between the source and the workers. Radiation source should be shielded and located in a room with lead or concrete walls and the controls being outside the room. Until the room door is not closed the control should not start (interlock).

Where more than 20 radiation workers work, Radiation Safety Officer is recommended. Personnel exposure and health (medical exam) records should be maintained. Radioactive waste (leaking sources, contaminated equipment or decayed sources) should be stored and disposed in the prescribed manner.

See Part 5 of Chapter-28 also.

(3) Ultrasonic:

IS 2417, 9346 & 11630 are on this subject.

Ultrasonic is an inspection technique to test both metallic and non-metallic products such as welds, castings, forging, sheet, tubing, plastics and ceramics by using sound waves (vibrations).

It discloses the soundness, thickness or physical property of the material or nature of discontinuities without impairing the material and by exposing its one side only. Ultrasonic waves i.e. vibrations are created by an electronic generator and passed through a material due to its elastic properties. Vibrations above the human hearing range (20000 Hz) are called ultrasonic vibrations. An ultrasonic testing unit uses vibrations of about 5x10666 Hz (5 megahertz).

Electrical energy is applied to a piezoelectric crystal also called transducer which causes material displacement within the specimen. The transducer converts electrical energy into mechanical and vice versa. Thus transducer can transmits or receives the energy. Transmission of energy can be pulsed or continuous. Steel, water and oil can transmit ultrasound very well but air is a poor transmitter because of its low particle density. Velocity of sound in steel, water and air are 5.9, 1.48 and 0.33 km/sec respectively. Therefore water, oil (grease) or steel is used as a couplant between the transducer and the test specimen. The pulses (waves) return back (reflect) from discontinuities in their path or from any boundary (end) that they strike. The received reflections are displayed on a cathode ray tube (CRT). The quality of the material is measured in terms of energy lost by a sound beam as it travels through the material.

Normally two methods are used. In 'Contact testing' method the transducer is coupled to the material through a thin layer of couplant. In ‘Immersion testing' method, both the material and the transducer are immersed in a tank of couplant (usually water). Immersion technique is commonly used to inspect tubing; pipe and butt welds.

There are two types of test systems - Pulse - echo reflection and Through transmission as shown in Fig. 19. A third system known as 'Resonant frequency' is rarely used because its functions of 'thickness measurement' and 'bond or lamination inspection' are also performed by the pulse-echo system.

High speed ultrasonic scanning generally utilises the C-scan presentations (there are A, B and C-scan, three types of visual displays).

Three types of discontinuities can be detected (1) Inherent wrought and inherent cast (2) Processing and (3) Inservice discontinuities.

A discontinuity is not necessarily a defect until the inspector-identifies and evaluates its negative effect on the service of the part or to the requirement of the specification.

Biological effects have been noticed on workers. Shielding of electrical connection causing electromagnetic fields, sound isolated booth, use of cotton lined rubber gloves, absorbent lining to tools, ear muffs, noise & vibration control, and periodic medical examinations are necessary.

(4) Magnetic Particle Methods :

Mostly forgings are tested by this method. Finely ground ferromagnetic particles of different forms and colours are available. Depending on the condition of surface to be inspected and type of indication to be located, form of particles and type of method - dry, wet or fluorescent - are selected. Colour is selected to have full contrast with the surface.

Then magnetic field is applied by DC or AC (low volts) current. This attracts and holds magnetic particles right on the surface. Defects if any, interrupt the magnetic field and are clearly shown by the pattern formed by the particles. Nature of discontinuities (defects) is disclosed and acceptable and unacceptable material can be separated in accordance with predetermined standards. After the test is over, the part should be demagnetised by reversing and reducing the magnetic field.

Local exhaust is necessary to control dust particles. If it is not possible, dust mask (respirator) and eye and skin protective equipment should be worn by the workers.

Smoking should not be permitted near wet bath process. Electrical arcing (caused by loose contact, excessive current or slipping of prods) can cause sparks or fire. Filters should be used on the black light while testing with fluorescent particles, to protect skin or eyes.

Burns can be caused due to resistance heating in the part or in the prods. Therefore these parts should not immediately be touched after the test.

IS 3415, 3703, 7743, 10724 and 10543 should be referred for details.

(5) Eddy-current or Electromagnetic Method:

Eddy current, magneto-inductive and radar frequency - three types of methods are used.

In eddy current method, an eddy current is induced in the part to be tested by passing alternating current in a coil or probe. Defects cause changes in the strength and distribution of the eddy current. Readout is presented on a cathode ray tube, on a meter or by audio-visual alarm. IS'.12965 should be referred for details.

In magneto-inductive method, variations in the permeability of magnetic materials are used to create variations in a probe or pickup coil.

In radar frequency method, high frequency radar waves are used to measure electromagnetic properties of thin coatings and surface layer of material. Workers should not pass in between the object being tested and the testing device otherwise they may burn internally. Barriers should be provided to the area.

(6) Dye Penetration Test :

Organic compounds or dyes are used as a penetrant which is applied on the surface after cleaning it. By capillary action (Capillilarity) the penetrant is drawn into discontinuities or defects and flaws (cracks, pores, leaks). Time is allowed for penetrant to seep into the opening. The excess penetrant is removed from the surface by cleaner and the developer is applied in the form of a thin uniform white layer, which absorbs the entrapped penetrant from the surface flaws and brings it up as a visible indication. It remains visible in defects until removed by cleaner like water, solvent or an emulsifier followed by a water wash. A coloured dye penetrant contracts with the surface colour in white light while a fluorescent penetrant shows defects under ultraviolet (black) light.

The penetrant should be non-corrosive, non-toxic non-destructive and having low halogen and sulphui contents.

Skin contact should be avoided. Skin should be washed just after exposure and before eating, drinking or smoking.

IS 3658 and 12889 should be referred for liquid penetrants for flaw detection.

(7) Strain Measurement:

Like non-destructive testing, condition monitoring is the measurement of the state of the equipment including pressure vessels, other vessels, pipework and machinery and it is carried out during construction/ fabrication and operational life. It is based on the performance or condition of the equipment. Various methods employed include following :

1. Corrosion monitoring.
2. Vibration monitoring.
3. Performance monitoring.
4. Thermal image monitoring.
5. Sound level monitoring.

6. Strain measurement.
7. Temperature measurement.
8. Speed measurement.
9. Torque measurement.
10. Position measurement.

Thus strain measurement is one of the condition monitoring methods. Any material undergoes stress (due to pressure or force) or strain (due to stretch or pull) depending on forces acting on it. Major forces are mechanical strain and pressure and temperature.

Following methods are used for strain measurement.

1. Strain gauges.
2. Displacement measurement.
3. Lacquers and coatings.
4. X-ray diffraction.
5. Interferometry utilising Moire grid. Speckle and holographic method.

A strain gauge (electrical) measures strain in one direction only and it is less sensitive. Interferometric techniques measure a two dimensional strain and are more sensitive. In Moire grid method a linear grid is applied to the object and its distortions are measured.

Photoelastic coatings and brittle lacquers are used to detect strain existence. The holographic method takes a silicone replica of the strained surface and analyses in a laboratory using powerful laser.

15.5.3 Role of a Competent Person :

See Part 6.8 of Chapter 6.

U/r 61 of the Gujarat Factories Rules, a recognized competent person has to carry out different tests of a pressure vessel. This includes external, internal, hydraulic and non destructive tests. He has to feel Form No. II, GFR, and has to suggest defect and remedial measures if any.

Under Static and Mobile Pressure Vessels (Unfired) Rules, a recognized competent person has to carry out tests, examination, inspection and certification for installations and transport vehicles. U/r 19 periodic hydraulic testing is required at an interval of five years. U/r 43 certificate of safety in prescribed proforma is required from a competent person.

15.5.4 Records in prescribed Forms :

Some statutory forms and proforma as stated above are to be filled after necessary tests and to be signed by a competent person. Where statutory proforma is not prescribed, competent person has to design it requiring relevant information. Such prescribed forms/proforma should be shown to the inspector on demand.

15.6 Corrosion, Erosion, Causes, Inspection and Prevention

Reasons of Pressure Vessel Failure are many. Wrong selection of material of construction, mechanical failure due to overpressure, overheating, external loading (e.g. platform, stairs, ladders, supports, brackets etc.), excessive stress (uneven or over tightening), brittle fracture, creep (due to fire or maloperation), mechanical fatigue and shock (due to pressure or flow variations, vibrations, expansion effects), thermal fatigue and shock (due to temperature difference and rate of change of temperature), hydrogen attack (blistering or embrittlement) and corrosion failure are some of the reasons.

Corrosion is an electrochemical reaction between a metal and its environment. It results in a loss of metal or weakening of it Corrosion reaches deeply, creates maintenance problems and incurs cost of loss in lacs of rupees over the years.

Corrosion failure has also many reasons to occur. General, local and external corrosion, galvanic, crevice, knife-line, intergranular and stress-related corrosion, scaling, exfoliation, corrosion pitting and erosion are some common types of corrosion in process plants including pressure vessels.

Corrosion due to oxidation at high temperature is called scaling, e.g. steam boilers. Exfoliation is a type of scaling caused by oxidation in steam atmosphere e.g. feed water heaters. General corrosion takes place due to a corrosive chemical or impurity over the exposed surface.

Intergranular corrosion occurs in stainless steels heated upto 500-800 °C and then exposed to corrosive conditions.

Galvanic corrosion happens due to current flowing between tow dissimilar metals which form a galvanic cell. It occurs when two such metals are joined together at a weld. A typical pair is iron and copper.

Corrosion pitting results from electrochemical potential set up by differences of oxygen concentration inside and outside the pit. The oxygen-lean part acts as anode and the metal surface as cathode.

Knife-line corrosion takes place between parent and weld metals, e.g. austenitic stainless steels.

Crevice or contact corrosion occurs at the point of contact of a metal and non-metallic material, e.g. threaded joints.

Erosion is a type of corrosion and is caused by flow restriction or change of direction, e.g. elbows, tees, baffles, nozzles and valves and point opposite to inlet nozzle. It is increased if the flow contains solid particles or by bubbles in liquids and by two phase flow. Wet steam flow, air jet flashing flow and pump cavitation can cause severe erosion.

External corrosion occurs by material of insulation. Leaching of chloride salts from insulation can corrode pipework.

Underground piping can be corroded by soil due to electrochemical action and cathodic protection is used to control it.

Stress corrosion cracking is the result of corrosion and static tensile stresses. Corrosion fatigue is caused by corrosion and by alternating fatigue stresses. Chlorides are a common cause of stress corrosion cracking. Stress may be internal or external. Stress corrosion cracking caused by an alkaline solution is known as caustic embrittlement, which has been a frequent cause of failure in boilers. Therefore treatment to boiler feed water (removal of caustic and chloride content) is necessary. Control measures are elimination of corrodants, reduction of residual stresses and vibrations etc.

In plants handling nitric acid and nitrates, "nitrate stress corrosion cracking" of mild steel is possible. This was the reason of crack in the reactor at Flixborough resulting in removal of the reactor and temporary installation of the 20" pipe which gave way and the disaster took place.

At high stresses and temperatures, traces of other metals like zinc can cause rapid and severe **zinc embrittlement** of some types of steels. Wetting of the steel by molten zinc is a favourable condition to zinc embrittlement. This may cause local fire and catastrophic failure. To avoid this, zinc-coated items should not be placed in direct contact with stainless steel or in positions where they can drip molten zinc on it. For example galvanised wire netting used in insulation should not be in direct contact with stainless steel pipe. During welding and fabrication, zinc contamination of stainless steel should be prevented. Special metallurgical examination will reveal zinc embrittlement.

Corrosion Prevention is of high importance as it prevents accidents and reduces cost of corroded materials. Substitution of non-corrosive or less corrosive material (e.g. SS instead of MS) tolerated by the process technology and economy and selection of such material from the design and erection stage avoids most of the corrosion problems. Then selection of powder coated metal parts (sheets, structural members, machine parts, guards, covers etc.) instead of painted, give long life. Mild steel parts of tanks structures piping, machines and vessels must be regularly painted by anti-corrosive paints. Protection from rain and plant water, dripping and leaking of corrosive chemicals, oxidation and contact of zinc and copper is necessary. Rapid cleaning of spillage, good housekeeping, cathodic protection, control of flow, fluctuations and vibrations, water softening and removal of salts, checking of scale formation on plates and tubes, thickness measurement and defect monitoring by NDT methods stated in foregoing Part 9.5.2 and latest instruments and equipment, scanning by computer methods, descaling, dechoking, scrapping, timely repairing and preventive maintenance are also useful to avoid corrosion and erosion.

Other methods to stop corrosion and erosion are as under :

1. Two compatible metal prevent or slow down the rate of corrosion.
2. A strategically placed gasket i.e. to provide insulating material between the two metals.
3. Cathodic protection and conversion coating.
4. Crevice corrosion can be avoided by choosing materials having corrosion resistance. Stainless steels are prone to crevice corrosion and not recommended for such use.
5. Dezincificaiton (removal of zinc from brass) can be prevented by using alloys of brass containing Sn, As, P or Sb.
6. Use of non-metallic material like plastic.
7. Applying monomolecular film (inhibitor) of grease, paint, synthetic organic coating or a plastic sheet (liner) over the surface.
8. Use of oxygen scavengers (e.g. Sodium sulphite and hydrazine) to add into boiler water to remove oxygen.
9. Inhibitors like phosphonates are used in cooling water for corrosion control.
10. Use of acid pickling as corrosion inhibitors.
11. Use of heavy oils or greases, waxes dissolved in solvents or sulphonate salts dissolved in petroleum as a barrier between die environment and the metal surface.

    However it should be verified that chemicals being selected as inhibitors should not be carcinogenic.as they can cause cancer. For example p-t-butyl benzoic acid, sodium nitrite, nitrosamines, thiourea etc. are carcinogenic and should not be used.
12. Non-metallic materials like plastic, rubber and synthetic elastomers can also be attached by corrosion or cracking due to solvent, environmental stress or thermal effect. Corrosion process in plastic takes place because of swelling, softening or loss of physical properties. Polyurethane, polyethylene, polystyrene, ABS, acetal homopolymers and polyethersulfone are the plastics having good resistance against corrosion.-

Rubber lining (e.g. chloroprene, nitrile and butyl rubber) on steel tank prohibits attack of strong acids.

15.7 Safe Start-up & Shutdown Procedures

Start-up or restart operation after a short or long shutdown and shutdown procedures need special precautions.

Starting sequence should be well defined, written and known to the workers involved in this work. Starting in sequence of utilities like water, air, power; purging, charging, slow and gradual heating, monitoring of pressure, temperature, flow and reaction rate, cooling if necessary, starting of exhaust system, scrubber or condenser etc., observing noise, vibration, speed, alignment, synchronising etc. are all important.

During start-up if drains remain open, vent valves remain closed, wrong valves are operated, unwanted material enters e.g. oxygen instead of nitrogen as blanketing over flammable reaction, water where it is incompatible, air instead of steam or steam instead of air, excess or less charging of material or catalyst, delayed cooling or heating, not starting of any pump or instrument, no indication or alarm due to failure or malfunctioning of instrument in the beginning, no starting of local exhaust or scrubber when it is essential and failure of interlock or trip resulting in unwanted mixing or reaction, mixing of air with hydrocarbons, contacting hot oil and water, thermal or mechanical shocks etc. are some of the examples of possible disorders.

Correct identification of pipelines, valves and gauges, correct sequence of control operation, correct charging or addition-rate and instead of relying on instruments only Counter-check of other parameters and strict manual observation and satisfaction are requisite precautions for safe start-up procedure.

Attention should be paid on preparatory activity, verifying content, removal of air or venting, purging and disposal of purged material, removal or addition of water, slow and sequential starting of heating or cooling, gradual reaching of working parameters and normal operation.

Other points needing attention in start-up are removal of shutdown blinds, providing running blinds, opening of scrubber or discharge line valve, opening of isolation valve before safety valve, starting of local exhaust ventilation, pump cooling and priming, readiness of fire fighting equipment, leak detection, opening vents and drains before allowing steam in the system, partial opening of steam valves, introducing steam from the bottom part, observance of level and overflow if any, safe increase in loading, avoidance of incompatible material, avoidance of moisture and impurities in breathing air, purging of blow down tanks and flare, removing air from vacuum equipment, inspecting joints and valves for leakage, verifying steam traps working for condensate discharge, safe displacement of steam, water or purge gas after their use, removing residual water before, introducing hot oil (initially cold oil should be introduced), using heat-exchanger for indirect and gradual heating or cooling etc.

Shutdown operation needs sequential steps like cooling and de-pressuring, pumping out, removal of residual content e.g. hydrocarbons, corrosive or toxic chemicals, water, oil, pyrophoric catalyst, disposal of effluents and sludge, drainage and blinding and isolation activities.

Heat source should be cut off, cooling may be continued till required, where vacuum is possible due to cooling, inert gas or air (if compatible) should be introduced to maintain atmospheric pressure, pumping out material after cooling and de-pressuring and pumped out hot oil should be cooled below its flash point. Residual hydrocarbons can be removed by purging with steam, water or water followed by steam. After purging, air should be allowed into the system. Residual water should be removed. Lastly running blinds should be removed and shutdown blinds should be installed.

If the shutdown is required due to any fault, the cause of the fault should be found, studied and removed before restarting the plant.

15.8 Maintenance

Maintenance should be considered as early as the design stage. Good engineering initially can reduce maintenance problems considerably. Those parts of equipment that need frequent attention should have good accessibility and be easy to remove or replace. Space must be available for tools or special maintenance equipment such as lifting gear, jacks or large torque wrenches. The planned maintenance system that is introduced should include plant condition monitoring. This enables the state of the plant to be deduced whilst still in service, cutting maintenance costs considerably compared to strip-down inspection methods.

Any planned maintenance/condition monitoring system should include a breakdown maintenance repair and analysis system. This enables modifications to be made subsequently to such schemes by modifying maintenance periods or adding or subtracting other operations. It will also help to identify poorly designed or constructed plant and enable better specifications to be produced for replacement items.

The third safety objectives is to train operators in the correct operating procedures. As all installed plant, including pumps, tankage, electrical systems and • instrumentation is the responsibility of the operations department, operating procedures must include safety regulations which prohibit unauthorised access to equipment. This is done by means of a work permit system.

Maintenance Policies and Types :

British Standard BS 3811 - Glossary of maintenance terms used in tero technology - defines terminology used for maintenance policies.-

Like health & safety policy or good quality assurance policy, a maintenance policy should also be defined to include breakdown or corrective maintenance and preventive or planned maintenance. Then it is possible also to develop a check list for plant maintenance.

Maintenance includes planned or scheduled shutdowns or stoppage of work to see all inaccessible (during normal working) parts also. Such periodical and planned in advance shutdown is a preventive maintenance. Instead of such a fixed schedule, "condition based' maintenance is also possible to carry out condition monitoring. Mostly NDT techniques are employed in condition monitoring.

Various types of maintenance and terminology used in BS 3811 are explained in Fig. 18 in a decision tree form

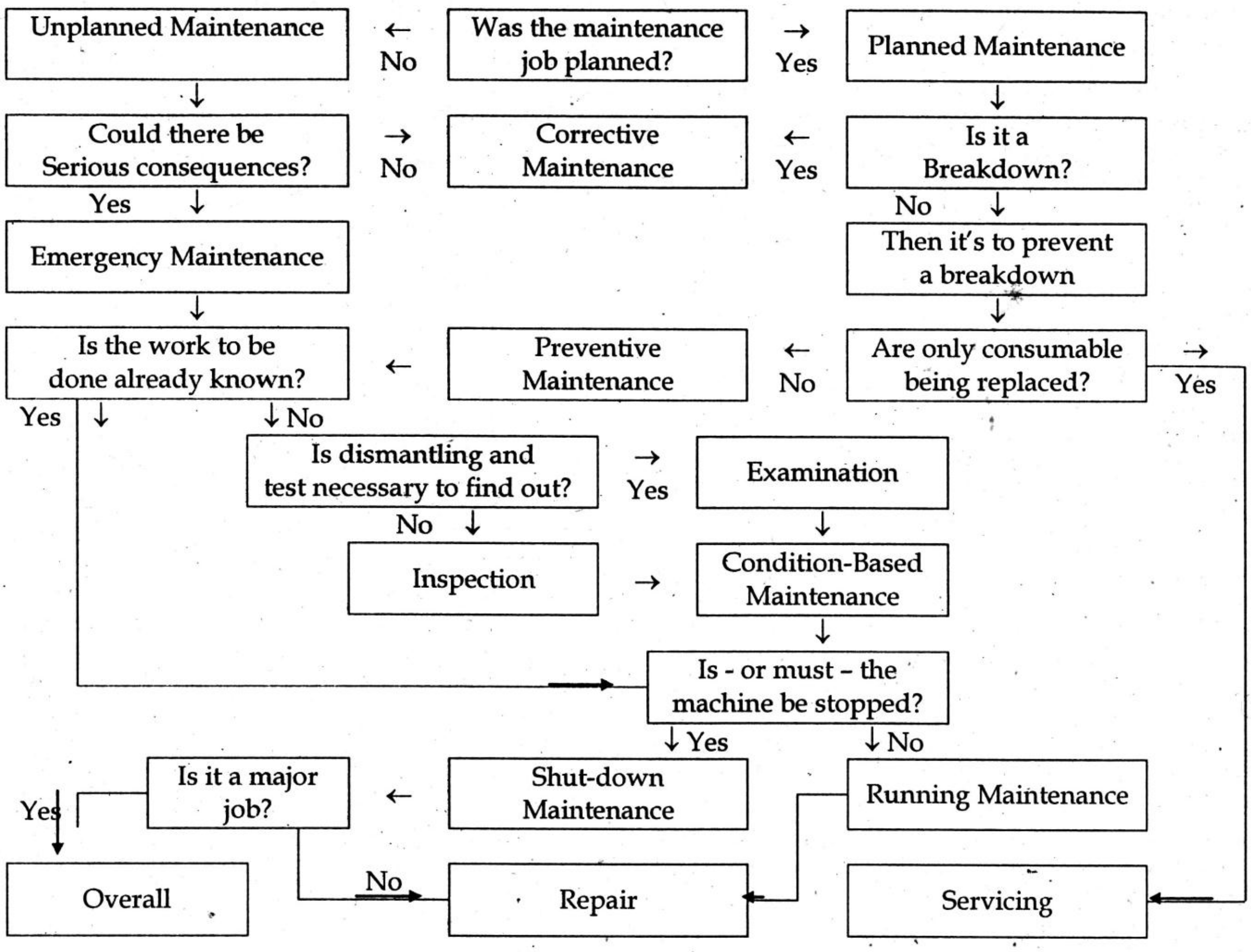


Fig. 18. : Decisions on Maintenance

Main intention of any maintenance system is to identify failure situations and by timely repair, replacement and servicing to stop the possible failures. This certainly saves subsequent costs of damaged plant, machinery, equipment, material and stoppage time and accident costs to persons, property and environment. Therefore maintenance cost must have due consideration and budgetary provision.

Maintenance activities include -

1. Running maintenance - rum-ling repairs with little interruption to production.
2. Servicing - replacement of consumable including lubrication and overhauling.
3. Production assistance - adjusting machine settings.
4. Breakdown, Corrective or Emergency Maintenance - unscheduled repair to broken parts.
5. Condition-based maintenance - unscheduled testing and repair based on unsafe condition noticed.

6. Shutdown or Preventive maintenance - scheduled (planned) or periodical testing and repair including servicing.

Maintenance activities may be of the type Emptying, purging, cleaning, breaking of pipelines, repair, demolition, hot work, welding, hot tapping, part removal, repair and refitting.

Information from reliability engineering (see Part 5 of Chapter-19) is quite useful to plan preventive maintenance. Identification and qualification of failures that may result in accident or hazardous condition, plant downtime or direct repair costs are useful. Main failure regimes of equipment are early failure, constant failure, random failure and wearout failure. Reasons of early failure include (1) Incorrect design, specification, selection and construction or manufacturing faults (2) Incorrect fault finding, repair method, replacement parts, refitting and bad working conditions and (3) Start-up mechanical or temperature stresses.

Repair, reconditioning or replacement should be carried out as per original design, specification, material and technique. Regular inspection can reduce maintenance. Now a days on-line testing, monitoring and inspection techniques reduce the breakdown maintenance.

Steps in preparing for maintenance are (1) Identification of plant or part (2) Its isolation and (3) Other preparatory measures such as venting, cooling, depressuring, purging and cleaning.

Maintenance can be made safe and systematic by work permit systems (see Part 1.8 of Chapter 19 and part 16 of this Chapter), audit of permit systems, tags and lockouts, power or content isolation.

Proper tools, lifting machines and equipment and personal protective equipment should be used while maintenance work.

16. WORK PERMITS FOR HAZARDOUS WORK

See also Part 1.8 of Chapter-19.

The objectives, methodology, issue of permit, its execution and termination, foreseeing of hazards and arrangement for their controls, testing and certification of working atmosphere, use of tools and personal protective equipment, first-aid and rescue equipment and training of workers for such work are the common factors in any type of work permit application. Its sole purpose is to save life and avoid accident.

Hazardous substances are many. They may be explosive, flammable, toxic, hot, corrosive and may be in the form of dust, gas, vapour, steam, hot oil etc. They pose high degree of hazards, have caused many accidents world-wide and need strict safety precautions while working with them.

Other factors being common, the vital part of devising any safety work permit is to concentrate on typical hazards involved and then to apply their remedial measures. Material Safety Data Sheet will expose property hazards. Storage, process and vessel conditions can reveal their specific hazards (Parts 6 to 17 of this Chapter discuss such hazards in details) and due consideration to all such hazards is necessary before devising any substance wise work permit. Statutory provisions mentioned inchapters 27 & 28 also supply useful and mandatory information.

Normally hazardous works of maintenance or modification need work permit system. It is given for the following category of works :

Operations	Excavation, vessel entry, working at height, hot work, welding and cutting, equipment removal, pipe breaking, line breaking, lining in furnace, waste disposal, ship breaking and cutting.
Equipment	Electrical, pneumatic, hydraulic lifting machine, crane, sprinkler or hydrant system.
Hazardous area	Explosive, flammable, corrosive, radioactive or toxic atmosphere.

Time Overtime or after hours work.

General and special hazards both should be considered. For example, work with flammable dust, gas, vapour or liquid requires flameproof equipment and avoidance of all sources of ignition, but depending upon the class of fire, specific fire extinguisher is required. Work with a toxic dust or gas needs local exhaust or capture device, but depending on type (e.g. chlorine, phosphine, CO) and concentration, specific respirator is required. Work with corrosive acid needs acid-proof hand-gloves, goggles and apron, but depending on fumes given by it (e.g. HCl, SO, nitrous fumes) specific respirator is required. Work with hot substance requires shielding and hand protection but depending on its nature (e.g. steam, oil, molten metal, liquid glass, hot surface), the specific type of hand protection (cotton, leather, asbestos) can be selected. Working on a fragile roof needs a crawling board, substantial platform or support and a safety belt but the height, place and position will decide the type of ladder or platform and type of anchoring as specific requirement. Work with dust requires exhaust or suction device but the type (e.g. sand, coal dust, wood dust, chemical powder, bio-organism) and size (microns) decide specific type of respirator.

Knowledge of appropriate solvents, scrubbing media, absorbers, adsorbers and inactivating substances is always useful while preparing work permit for any specific substance.

Knowledge of right type of tool, tackle, equipment and instrument helps in suggesting work with safety.

Work permit to demolish or repair any tank, vessel or equipment needs special precautions. Inner content should be identified and removed before allowing any hot work. The atmosphere must be rendered non-flammable. Residues lie not only on the bottom but also on the walls and may evolve volatile material and catch fire. Polymer residues normally lie on the upper walls or the roof. To remove such residues first requirement is to clean them. Cleaning can be performed by hand cleaning, machine cleaning or steaming out. Bottom residues can be covered by water or protein foam as blanketing. Inerting is also possible but this needs oxygen reduction below 10% to carry out any hot work on the tank.

Where liquid content (residues) is of low flash point (e.g. $<40\ ^0C$), the tank may be fully filled with water and then cold cutting (using pneumatic chisel) method may be applied. Cutting should start from the top and proceed toward bottom. Here the vapour space is minimised, resulting in turn, minimisation of the hazard. But the tank should be capable of withstanding the water load.

In another type of method, high expansion foam (e.g. 40 m^3/min) can be used as a blanket. Heat exchanger containing flammable vapour can be filled with water and crushed for demolition.

However it should be noted that all such techniques require special knowledge and need of an expert/competent person.

16.1 General Checklist:

A general checklist (Format) of permit for Hazardous Work is given below in Table 18.9.

Table 18.9 : Work Permit for Hazardous Work.

Name & Address of the Factory : ________________________________ Sr. No. : _____________
Name & Address of the Contractor : ________________________________ Date. : _____________

Permittee (the site supervisor)			Plant/ Section	Location of the work to be done	Date & time of issue (Permit)	Date & time of expiry (Permit)
Name of the person	Designation	Company				

Description / Nasture of the work to be done. (to be filled in by the permittee)	**Equipment/ tools/ hazardous substances to be used** (to be filled in by the permittee)	**Probable Hazardous** (to be filled in by the contractor's site engineer)	
	☐ Crane (No _________)	☐ Fall of persons from height ?	☐ Suspended load ?
	☐ Chain pulley block.	☐ Falling objects/ overhead work ?	☐ Fire ?
	☐ Slings & other lifting tackles.	☐ Fall below grade level ?	☐ Toxic / flammable dust / fumes/ vapour ?
	☐ Electrical equipment?	☐ Electrical shock ?	☐ Exposure to hazardous substances ?
	☐ Portable electrical tools ?	☐ Moving machinery ?	☐ Damage to underground service, line, etc.
	☐ Scaffolding / work platform ?	☐ Ionising radiation?	☐
	☐ Hazardous substances	☐ Eye injury (flying objects / arc) ?	☐

The following requirement / safety measures are necessary and have been provided/ ensured.	Following safety measures/ precautions to be taken during execution of the job	Special precautions to be taken (if any), please specify.
☐ Proper scaffolding/ work platform with handrails.	☐ All workmen use safety helmet at the site.	
☐ Means of access to work place at height (ladder, etc.)	☐ Workmen use safety belt & anchor it properly with fixed structure.	
☐ Safety net (Catch Net)/Static lines to arrest fall of person.	☐ Use of proper safety goggles by the workmen.	
☐ The crane is in good working condition & certified	☐ Provision of shoring / bracings in deep excavation.	
☐ The crane operator is competent & has licence.	☐ Guards on moving machines.	
☐ Electrical equipment provided with proper earthing.	☐ Static lines are provided and used by the workmen at height.	
☐ Power supply to hand tools through ELCB.	☐ Cordoning off deep excavations / hazardous area with warning signs.	
☐ Hazardous area barricaded /protected.	☐ Hand lamps to be used with safety guards.	
☐ Condition / capacity of lifting tackles ensured.	☐ Power supply to lighting through ELCB.	
☐ Specific work procedure is necessary and is available.	☐ Specific work procedure shall be adhere to.	
☐ Hot work / vessel entry permit is necessary and obtained.	☐ Familiar with emergency procedure.	
Signature (Contractor's Site engineer)	Signature (Contractor's Site Supervisor)	Signature :

Name :	Name :	(Site engineer)

Copy to : Safety Dept./ Contractor

16.2 Permit for Vessel Entry:

For the definition of 'Confined space' and other details, see Part 2 of Chapter-16.

Safe entry in any confined space like pit, sump, vessel, vat, tank, chamber, furnace, oven, pipe, flue, gutter or isolated and unknown place needs work permit system. The hazards of work are toxic or flammable gas inside, asphyxiating atmosphere, accidental inflow of chemical or starting of agitator etc.

See Part 1.8 of Chapter-19 for formats of safety permit and details wherein provision of Section 36 of the Factories Act is also mentioned.

More danger is foreseeable when any gas or vapour - visible or invisible, having odour or not heavier than air (vapour density > 1) is suspected in the confined space. Fatal cases have been reported. No person should enter or allow another person to enter such situation without going through the following steps :

1. Report the need of such entry to higher officer whose duty is to prepare and sign a necessary work permit for such work.

2. Work permit will be prepared after observing the situation from outside, allowing the vessel to be cooled and giving full thought to all the safety points to be incorporated.

3. If it is an underground pit, sump, chamber or tank having no connections except a manhole at the top, the manhole should be opened after wearing a self breathing apparatus, free air movement and venting should be allowed for some time and then the gas test and the oxygen level test should be carried out. Toxic gas should be safely driven out by air purging and a flammable gas by nitrogen purging. The worker doing this job should be experienced and wearing self breathing apparatus. Such work should be carried out during day time with good natural lighting. While replacing any flammable gas or hydrocarbons, sources of ignition must have been removed and non-flameproof electric lighting/fitting deenergised. Only a flameproof torch may be used. To avoid static electricity, airline should be bonded with the metal of the vessel.

4. After evacuating gases as above, again their level (ppm in case of toxic gas and percentage in air-LEL-in case of flammable mixture) should be measured and brought down to a safe level. But this is not sufficient. Oxygen content should also be measured and it should be more than 18%, otherwise specific instruction of SBA shall be mentioned in the work permit.

5. If it is a vessel, tank, reactor, pipe or other space having nozzles and connections, first top and bottom, vent and drain/flush valves should be opened to discharge lighter and heavier gases. Inlet connections should be isolated, blinded or removed from joint. By nitrogen purging inner gases should be fully pushed out. Then the vessel should be washed and drained by steam and water if it is not incompatible. Then the manhole and other top and bottom connections should be removed making the top-bottom nozzles fully open for better (cross) ventilation and lighting. This ensures that neither heavier nor lighter gases will remain inside and free entry of air will keep the space breathable. Otherwise positive air supply should be provided. If it is not possible to open any joint except manhole, the procedure stated in para 3 and 4 should be followed.

6. After ensuring ambient condition and isolation or disconnection of inlet lines, opening maximum nozzles possible (at least flush bottom drain and top vent), removing or isolating any common connection (e.g. header or common vent or scrubber line) and measuring gas and oxygen content to a safe level, electric connections (e.g. driving motors for stirrer, pump, blower, exhaust, vacuum or any ingress or egress of material) shall be removed (by removing fuses and indicated by a warning notice and tagging) and the overall situation shall be verified for safe entry.

7. Only after assessing the real need of entry and verification as above, the work (vessel entry) permit shall be signed and safety precautions mentioned in it shall also be verbally explained to the permit holder and the worker who has to enter inside. The issue of permit should be done by a responsible and experienced person only.

8. If it is not possible to achieve safe working level inside due to presence of toxic gas or less oxygen content, the condition of self breathing apparatus and a safety belt having its free end (life line) in the hands of a capable person standing outside to pull him out, and first-aid and rescue/reviving apparatus in ready condition, shall be clearly mentioned in the work permit and explained to the workers and supervisor.

9. If work is to be carried out of replacement of any pyrophoric catalyst under nitrogen blanketing or of removal of any deposit, scale, sludge, waste or lining inside, instructions stated in para 8 shall be strictly observed.

10. Now after receiving the permit, it shall be fully understood before execution. All conditions shall be fulfilled including wearing SBA, safety belt and necessary equipment. Environment shall be cool for entry and safe working. Manual bell may be carried to give signal of any emergency situation and indication to pull the life line or supplying any thing necessary.

11. Air line respirators are not safe because of the possibility of detachment of air supplying pipe. Canister gas masks are also not advisable. A self breathing apparatus with low pressure alarm seems to be the safe remedy.

12. After the work is over, the permit shall be signed and returned to the person who issued it. Experience or suggestion if any shall be mentioned to make the future work more safe.

If the work cannot be completed in one shift- or within time limit mentioned in the permit, the permit should be submitted for extension before continuing the work

No statutory format is available. A company can devise a format best fitting to their nature of jobs. Items to be included in such format are - Place of work, work to be done, whether withdrawal from service, isolation, cleaning and purging, testing, conditions, expiry time and authorisation to work, acceptance of certificate, completion of work, extension is required, permission of extension, cancellation of the permit and provision for signature, date and time.

Isolation of pipelines and electric power should be positive and effective. Mere closing of valve or switch is not sufficient.

If a worker inside becomes unconscious or is in trouble, entry for rescue shall be allowed with SBA, safety belt and other persons standing outside to pull the life line (with head up). If this is not done, multiple fatalities are possible.

17 REPORTS OF SOME EXPERT COMMITTEES

After the Bhopal disaster on 3-12-1984, various expert committees were formed by the Central and State Governments and their reports are also published. Some such reports are : Government of India's Safety Policy and SAHARA Plan, Gujarat Task Force Committee's Report, and its Empowered Committee's report, Maharashtra Environmental (Garg's) Safety Committee's Report, ILO Committee's report. World Bank and IFC guidelines and Report of the Inter— ministerial Group, Department of Chemicals and Petrochemicals, Ministry of Industry, Govt. of India. The details of all these reports are beyond the scope of this Chapter. It is recommended to study them to consider experts' findings and views on chemical safety. All India Citizens' Report published by the Centre for Science and Environment, New Delhi-110019 is also worth considering. The abstracts of all these reports are readily available in Reference No. II given at the end of this Chapter.

General recommendations of some such reports are given below in brief.

17.1 Garg Committee's Report (1985)

In addition to the specific recommendations, the Committee suggested the following general recommendations which should be implemented by all the factories and the concerned agencies to avoid major mishaps :

1. The operators should be adequately trained in handling abnormal situations in plant operations and refresher courses should be arranged for them regularly.
2. Toxic gases in the factory environment should be continuously monitored.
3. Safety devices and instruments in the plant should be frequently inspected, tested and a record kept.
4. Storage of intermediate products which are hazardous in nature should be restricted to eight hours requirements and before any plant shut down all such intermediate products should be consumed.
5. Risk analysis should be carried out in all the plants where hazardous chemicals are handled and measures for containment in case of such a risk be identified.
6. All factories handling hazardous chemicals should educate the neighbouring population (in consultation with local authorities) about measures to be taken in the unlikely event of release of any such chemicals.
7. All the containers, plant equipment and pipelines be made unserviceable when disposed of as scrap.
8. For transportation of hazardous chemicals, a safety code should be evolved by the competent authority.
9. New buildings and hutment should not be allowed to come upnear factories handling hazardous chemicals.

17.2 Report of the Gujarat Task Force Committee (1985)

The Government of Gujarat constituted a "Task Force" Committee under the chairmanship of Shri J.J. Mehta of Bombay to oversee the safety measures in various industries in Gujarat dealing with hazardous/ toxic materials, wide Industries, Mines & Power Department Resolution No. APC-1084/186(86)-G, dated 10-1-1985, Sachivalaya, Gandhinagar.

The Committee considered (1) Toxicity (2) Boiling Point (3) Fire & Explosive hazards (4) Reactivity and (5) Quantity of storage to identify hazardous chemicals and made a list of 27 such chemicals.

Observations : Major observations made by the "Task Force" are as follows :

(A) Identification of Potentially Hazardous Units :

The major units handling and having substantial inventories of hazardous/toxic chemicals are identified by this "Task Force" as A. High disaster potential and B. Low disaster potential.

The units in category A can be studied in greater details by an experts committee which should meet regularly, say once in two years to discuss various technological developments in the safety and share their experience. Agencies like Gujarat Safety Council can organise such meetings.

The units in category B can regularly monitor and review the safety aspects in such industries.

(B) Transportation of Hazardous Toxic Chemicals :

1. Transportation of all acids, oleum, corrosive liquids and toxic chemicals should be brought under statutory control. Transportation of such chemicals in poorly equipped, maintained carrier should not be allowed.
2. Tanker carrying acids and corrosive chemicals be regularly inspected for their thickness.
3. All the tankers should have two valves at the outlets. During transportation of filled tankers the valves should be blinded.
4. Pressurising with compressible fluid should be avoided for unloading.
5. The tanker carrying hazardous/toxic chemicals should not be allowed to pass through city/town if by-pass is available.
6. The go downs of transport agencies, for storage of hazardous/toxic chemicals, inside the city limits should not be allowed.
7. The transport agencies drivers carrying hazardous/, toxic chemicals should be educated and trained to tackle emergency situations on the road.
8. The manufacturers of hazardous/toxic chemicals should prepare a list of materials incompatible with the chemicals produced by them and tell the transporters not to carry them together.

(C) Safety of Surrounding Inhabitants :

1. *Existing Industries :* No new housing colonies/ slums should be allowed within 2 km from the boundary wall of the units identified to be having high disasters potential and I km from the boundary wall of the units identified as having low disasters potential. Local authorities should act immediately to stop construction of colonies within above boundary areas. The hutment dwelling should be relocated in safe areas.

2. *New Industries :* Govt. should not ask the new industries (proposing to handle hazardous/toxic chemical) to go to inaccessible locations and at the same time the unit should be located at a safe distance. The development of the area should be properly planned and controlled and haphazard development of housing colonies, slums should not be allowed around the industrial units.

G.I.D.C. can plan to develop chemical estate, with 'Hazardous Zone' (proposing to handle hazardous/ toxic chemicals) which could be located 1-2 kms away from the main estate.

(D) Medical/First-Aid Facilities:

1. The industries should have trained medical personnel to treat the workers.
2. Keep sufficient required antidotes, drugs etc. at the factory hospital. The doctor should have the knowledge about the chemical poisoning and the kind of treatment required.
3. Sufficient number of emergency breathing equipment and cylinders should be available in all the potentially hazardous industries.

(E) Fire Protection Arrangements and Provision :

1. The Units should have protection system with fire hydrants and water monitor and plenty of water.
2. A fire water line should be able to develop 10kg/ cm^2 pressure for fire fighting. The fire water pump should be able to run with emergency power. Diesel driven water pump should also be installed for use in case of total power failure. G.I.D.C. should ensure this for their major estates.
3. All the major units should organise their own fire brigades.
4. The fire fighting services with emergency breathing equipment and cylinders should be provided for combating fire hazard in toxic atmosphere.
5. Fire stations of G.I.D.C./Municipal Corporation etc. should have a few self contained breathing apparatus.

(F) Safety Management:

Top management of major units should actively participate in the safety management of their units and the head of the safety department should report to the top management directly. Safety officers should be appointed in major G.I.D.C. estates, having chemical industries.

(G) Disaster Plan:

The industries handling hazardous chemicals should prepare their own disaster plan involving the district administration, city fire service, medical personnel, police department, the people in the surrounding area etc. to avoid or minimise loss of life.

(H) Miscellaneous:

1. Small customers (hazardous/toxic chemicals buyer) should be educated by the major producers regarding certain preliminary DOS and Don'ts while handling the chemical.
2. The workers in the industries should be educated and trained to control emergencies and such programmes should be held at regular intervals. People living in the surrounding area should also be given certain preliminary information to handle emergencies.
3. Regular preventive maintenance and safety drilling should be carried out by the industries to check the workability of equipment, instruments, controls etc.
4. Pressure vessels should be regularly inspected for their thickness so that failure of such vessels due to corrosion, erosion etc. can be avoided.

5. Health hazard data should be collected.
6. Recycling of waste products should be carried out to minimise the effects of pollution.
7. Automation and remote control system should be followed to minimise manual handling.
8. The meteorological data regarding wind velocity, direction etc. should be collected.
9. Easy finance should be made available to hazardous units for providing safety measures.

17.3 An Extract of the Inspection by three ILO Experts on Inspection of 91 MAH Factories

The guidelines circulated by the CLI, Bombay, in Jan'91 are as under :

(1) General Recommendations.

1. A written safety policy, signed by a factory manager, should be framed and distributed to workers or displayed.
2. In preparation of the emergency plans more attention should be paid to an adequate emergency organisation, emergency control centre, external communication and phasing of activation of the emergency plan.
3. Qualified plant personnel should be trained in conducting HAZOP study and this technique should be applied in identifying .and controlling the hazards involved in the plant process.
4. Material Safety Data Sheets of hazardous chemicals handled in plants should be prepared and the workers should be made aware of these.
5. Preventive maintenance of the pipelines, storage and process vessels should be improved especially by incorporation of the non-destructive testing method. A regular schedule should be drawn and complied with.
6. Separate Work Permit Systems should be framed for cold work, hot work and vessel entry.
7. The piping and instrumentation (P&J) diagram of the installations should be updated and readily available.
8. The electrical fittings in the flammable installations should comply with the prescribed standards. The flame proof electrical equipment should be maintained properly.
9. The pipelines should be painted in accordance with the prescribed colour code.
10. Installations handling corrosive chemicals should be provided with emergency showers and eye fountains at appropriate locations.
11. Emergency fire fighting rehearsals should be carried out regularly at least once in two months.
12. It has to be ensured that sufficient quantity of water is available for fire fighting.
13. Standards and Codes used for design of the installations should be available at the factory.
14. A map of surroundings with a radius of 5 km around the factory should be drawn up.
15. On-site emergency plan drills should be carried out regularly.
16. Responsibility of authorisation of a plant modification should be assigned to a specified group of personnel.
17. Written Safe Operating Procedures should be available at the different units of an installation.

18. Adequate Personal Protective Equipment should be available to attend plant maintenance and emergency control work.

(2) Specific Recommendations for Installations

A. LPG

1. Sight flow indicators made of glass used in LPG discharge line should be guarded adequately to prevent breakage due to external impact.
2. LPG spheres and bullets should be provided with two level monitoring equipment independent of each other.
3. The remote operated valve should be provided in the outlet line of the LPG storage vessel and should be located as close as possible to manual outlet valve. These manual and remote operated shutoff valves should be fire resistant for at least 2 hrs. The manual valve should be fitted to the bottom nozzle.
4. One of the level monitoring instruments should automatically close the remote controlled shutoff valve, when the level of LPG has reached the maximum allowable limit.
5. The flow under the LPG spheres or bullets should be slopped in such a way that any liquid spillage of LPG may be directed towards an evaporation bed of gravel or a catchment pit and should be at least 15 meters away to prevent heating of storage vessel in the event of fire.
6. Any isolation valve fitted between a single pressure relief valve and upper space of the storage vessel should be locked open. Flammable vapour audio-visual alarms set to 20% of the lower explosive limit should be installed in the storage area and close to the evaporation bed or catchment pit.
7. The main cap of the vent line of LPG storage vessels should be loose fitting so that it blows off easily in case of pressure relief.
8. When any road tanker is being unloaded, the engines of all the road tankers in the unloading area should not be operated. Provision, should be installed to prevent inadvertent movement of the tank trucks when connected for loading or unloading.
9. The sprinkler system of LPG installations should be quick acting.
10. Any manual operated shutoff valve in the sprinkler system should not be close to the LPG storage vessel.
11. The surface area of the platform at the top of LPG storage vessel should be sufficient to avoid scaffolding for maintenance work.
12. Section of a LPG carrying pipeline between two block ends should be provided with a pressure relief device such as pop-off valve.
13. Excess flow valve should be installed in the inlet and outlet pipelines of the LPG bullets.
14. The areas around the LPG installation should be classified in relation to use of flame-proof equipment.
15. It should be ensured that all the earth connections provided for prevention of accumulation of electrostatic charge are maintained in good condition.

See Part 8.6.3 also.

B. CHLORINE

1. The storage vessel should be provided with two independent level monitoring devices. At least one of these devices should be provided with high and extra high level alarms and a trip action; or the vessel may be provided with a load cell which gives an alarm at a certain set weight. In this case first high level alarm has to be provided with a trip function.

2. The pressure relief valve on the top of the chlorine storage vessel should be provided with a bursting disc and an isolation valve. In between the bursting disc and pressure relief valve a pressure indicator and alarm should be installed to give warning of failure of bursting disc.

3. The isolation valve provided between vapour space of the storage vessel and pressure relief valve should be locked open. If two such relief devices are provided it should be ensured that at least one of the isolation valves is" always locked open.

4. Expansion vessels with a bursting disc should be connected to the liquid chlorine pipelines wherein liquid chlorine can be trapped between two close valves.

5. The expansion vessels should be provided with pressure relief valve venting to the neutralising tower.

6. A pressure indicator alarm should be installed on the expansion vessel.

7. A remote operating shutoff valve should be provided in the chlorine transferring line as close as possible to the storage vessel. This remote operating shutoff valve should be closed to the manually operated shutoff valve.

8. Excess flow vales should be installed in the liquid outlet lines of the storage vessels. This should be directly connected to the outlet nozzles of the storage vessel.

9. Emergency kit and personnel protective equipment should be available at a reasonable distance from the chlorine storage. These should be maintained in good condition and their location should be known to all the workers in the chlorine storage area.

10. An automatically operated pressure control valve should be installed on a storage vessel and receiver to control the air pressure while padding the liquid chlorine for transfer.

11. The dew point of the padding air should maintained below -40 °C, to minimise moisture content.

12. Chlorine toners should be stored securely in a raised platform.

13. The overhead crane in the toner "storage area should be provided with a proper lift beam to handle chlorine cylinders.

14. To contain the chlorine gas leaking from a toner suitable provision should be made to exhaust it through an alkaline scrubbing system.

15. All chlorine toners should be fitted with safely caps.

16. Chlorine toner storage area should be provided with a shed.

17. There should be separate areas for storage of filled and empty chlorine toners and these should be clearly marked.

18. A multipoint continuously monitoring chlorine gas detection system should be installed in those areas where chlorine gas can escape out of an installation. This detection should be provided with an alarm set at 3 ppm.

19. Emergency kit specially designed for checking the chlorine leakage from a toner should be available in the toner storage area.

20. Self contained Breathing Apparatus and Gas Mask with canister should be available and maintained in good condition. Their location should be known to all the workers for use in emergency.
See Part 8.6.1 also.

C AMMONIA

1. A bund wall should be provided outside the radius of a Horton sphere which should not be less than one meter in height. This bund should have minimum capacity to contain 20%" of ammonia content in the Horton sphere.
2. The bund should have impervious floor and provision for low point drain pit discharging flanged valve to remove any water collected. This flanged outlet valve should normally be kept closed.
3. A remote operated shutoff valve should be provided in the bottom outlet as close as possible to the storage sphere.
4. The isolation valves beneath the pressure relief valves should be kept locked open or interlocked in such a way that always at least one of the two is in open position.
5. Venting of Ammonia through safety relief valve should be at least ? meter above the platform at the top of the storage vessel. This vent line should be provided with loose fitting rain caps.
6. In. the Ammonia tank, truck and railway wagon loading/unloading station, technical provision should be installed to prevent trucks or rail wagons from being driven away while hose is connected. This could be a barrier which is removed only after hose and/or the load arms have been put back in its position.
7. The insulation of pipelines carrying Liquid Ammonia should be maintained properly.
8. An excess flow valve should be installed in the liquid Ammonia line of the Horton sphere. This valve should be as close to the sphere as possible.
9. A multipoint continuously Ammonia monitors with alarm should be installed in the storage and Ammonia handling areas.

See Part 8.6.2 also.

D. OLEUM

1. Oleum storage vessel should be provided with level indicator with high level alarm.
2. The high level alarm should automatically shutoff the valve in the filling line.
3. Oleum storage vessels should be provided with an acid proof bund having a capacity of containing 110% content of the biggest vessel in the group.
4. It is to be ensured that manually operated shutoff valves in the vent line connection to scrubber are kept locked open.
5. A second standby pump for the operation of the scrubber should be installed.
6. Provision should be installed to prevent inadvertent movement of the road tanker while it is connected for loading/unloading operation. This can be done by using handbrake, wheel blocks, and removing ignition key from the vehicle.
7. A schedule for preventive maintenance and inspection of equipment, storage vessels and pipelines handling Oleum should be drawn-up and complied.

8. Oleum storage vessels should be properly labelled to indicate its identity and capacity.

9. Pipelines carrying Oleum should be properly supported.

10. The road tanker loading area should be provided with an impervious acid 'proof slopping to a catchment pit. The pit should have enough capacity to contain the full leakage from the tanker.

See Part 8.6.5 also.

E. CARBON DISULPHIDE

1. Carbon Disulphide storage vessels should be fitted with two independent continuously level monitoring instruments of which one should be provided with high level alarm.

2. Properly designed rupture discs should be used instead of asbestos plates for the Carbon Disulphide manufacturing furnaces.

3. Safety seal outlet of the Carbon Disulphide furnace should be extended above the roof level.

F. OXYGEN

1. Oxygen storage tank should be provided with a pressure gauge with high pressure alarm. 2. A remote operated shutoff valve should be installed in the Oxygen outlet line of the Oxygen storage tank and should be as close as possible to the tank.

3. A non-return valve should be installed near the process pump discharge of the liquid Oxygen inlet line.

G. ETHYLENE OXIDE

1. Ethylene Oxide storage vessels should be provided with a second level monitoring instrument which gives high level audio & visual alarm.

2. The fire water tank should be provided with a level indicator.

3. The process reactors in the Ethylene Oxide plant should be provided with pressure relief valve and the relief discharge should be vented safely.

4. Ethylene Oxide reaction vessel should be provided with Oxygen detectors which gives high audible and visual alarm at the level of oxygen of 6%.

5. The bonding cables of static current equalisation system between tank truck and Ethylene Oxide storage vessels should be maintained properly.

EXERCISE

I. State, Explain, Mention or Discuss

1. Why chemical industry is inevitable despite its many hazards?
2. As place of chemical industry in society is inevitable, place of safety in chemical industry is also inevitable.
3. Statutory provisions pertaining to chemical factory.
4. Content of MSDS and its significance.

5. Expand : TLV, OSHA, LEL, PVRV, HAZOP, ILO, STEL, API, PPM, NDT.

6. The following terms (1) LD50 (2) LC50 (3) Explosive Range (4) Toxicity (5) TLVSTEL (6) MTRF (7) Mutagenesis (8) Chemical Asphyxiants (9) IDLH (10) Biological Monitoring.

7. Storage and handling procedure for the following : (1) Benzene (2) Hydrochloric Acid (3) Concen. Nitric Acid (98 %) (4) Carbon disulphide.

8. Safety and Risk phrases, their examples and utility.

9. Storage vassals and their safety aspects.

10. The general principals involved in a safe layout of bulk storage for flammable liquids, corrosive and compressed liquifiable or dissolved gases under pressure.

11. Safety measures required in storage and handling of following specific materials. (1) Flammable (2) Explosive (3) Corrosive (4) Toxic.

12. Hazards and Controls of Exothermic reaction.

13. Describe important aspects of pressure vessel inspection and the inspection of their protective devices.

14. Hazards and Controls of Toxic reaction OR Flammable reaction.

15. The various characteristics of unit operations and unit processes in a chemical process industry.

16. Which are the additional safety devices and fittings normally provided for pressure vessel in addition to those, which are statutorily required? Why are they so provided?

17. What are utilities? Explain their hazards and control measures.

18. Various types of operational deviations and control measures for them.

19. Different modes of packaging.

20. Precautions or emergency action while transporting hazardous chemicals.

21. Safety aspects of pipelines for transferring chemicals.

22. Importance of process flow chart for inspection.

23. Different types of inspection techniques for plant, vessels and procedures.

24. Inspection and testing of pressure vessels.

25. Different types of tests for pressure vessels.

26. Causes of corrosion and their preventive measures.

27. Types and methods of maintenance.

28. Different types of work permits for hazardous work OR confined space entry.

29. Explain the working principles of combustible gas indicator.

30. Define "Hazardous process" as per Factory Act and list 10 chemical covered under Schedule 1.

31. Important safety precautions to be observed in loading and transportation of a class-A' flammable and toxic liquids.

32. DOT Classification of hazardous chemicals. Mention safety precautions to be observed during transportation of hazardous chemicals by road including statutory requirements.

33. Plan to keep control on health hazards related to chemical factory handling toxic and poisonous chemicals.
34. As a Safety Officer of a chemical plant, what plan of action would you draw to reduce the accidents ? State giving priorities to different actions.
35. What safe methods for storing and handling you will suggest for following chemicals : (1) Benzene (2) Phosgene (3) Benzidine (4) Hydrochloric acid (5) LPG (6) EO (7) Oleam
36. Discuss the safety measures required to be taken in transfer of chemicals by pipe line in chemical factories.
37. The importance of identification of pipe work and colour coding in chemical factories.
38. The safety precautions to be taken in handling of chlorine in factories.
39. Basic steps for start-up of a plant after a period of closure.
40. "Reactor Safety" is of fundamental importance in Chemical Factories. Give basic considerations for safety of a reactor.
41. Various five prevention and five protection measures required in a process plant handling/steering processing highly flammable liquids /gases and toxic materials.
42. The safety measures that are required to be taken during storage and handling of gas cylinders filled with following gases. (a) Chlorine, (b) Phosgene, (c) Ammonia, (d) Acetylene.

2. Write Short Notes :

1. Need of Safely in chemical industry.
2. Types of chemical industry.
3. Types of hazards in a chemical factory.
4. Incompatible chemicals.
5. TDG flammability
6. Types of flammable material.
7. Health hazard data.
8. Hazard communication system.
9. Run away reaction.
10. Safety in chemical reaction.
11. Inspection checklist.
12. Protective media for safety purpose.
13. Safe handling and storage of Chlorine OR Ammonia.
14. Safe handling and storage of LPG OR EO OR Oleum.
15. Dyke walls and bunds around bulk storage of flammable liquids and corrosive substances.
16. Prepare an instruction checklist for storage/loading/unloading/ transportation of hazardous chemicals.
17. Safety in laboratory.
18. Process control system.

19. Safety valves.
20. Exothermic reaction.
21. Control System Characteristics
22. Instrumentation for Safety.
23. Safely aspects of instruments.
24. Transportation of explosives by rail.
25. Classes of dangerous goods for 4 transportation.
26. Different Codes for transporting chemicals by Sea.
27. Safety aspects of under-ground pipelines.
28. Identification and colour code of pipelines.
29. Precautions while breaking pipelines.
30. Safety aspects of in-plant transfer of chemical by different modes.
31. Nitrate stress corrosion cracking.
32. Non Destructive Tests.
33. Role of Competent person for safety of vessels OR Usefulness of checklists.
34. Safe start-up OR Safe shutdown procedure.
35. Vessel entry permit and precautions.
36. Safety suggestions of Garg Committee's Report.
37. Gujarat Task force Committee's Report for hazardous plants.
38. ILO Experts' inspection remarks for MAH factories.
39. Inter lock system for process control.
40. Trip system for process control.

3. Explain the Difference with examples between following;

1. Simple asphyxiates and chemical asphyxiates.
2. Dust hazards and bio-hazards.
3. Hazards of metals & non-metals.
4. Compatible and incompatible chemicals.
5. Fire & Explosion data and Health hazard data in MSDS.
6. CAS No. UN NO. and ADR No. of chemicals.
7. Flash point. Boiling point and Auto ignition temperature.
8. Hazardous decomposition products, Hazardous combustion products and Hazardous reaction products.
9. Vent pipe and Overflow pipe
10. Safely valve and Rupture disc.
11. Earthing and Bonding.
12. Unit processes and Unit Operations.

13. Exothermic and endothermic reaction.
14. Safety fitting for Pressure and Vacuum reaction.
15. Pyrometer and Thermometer.
16. Corrosion and Erosion.
17. (a) Hydrogenation &: Halogenation
    (b) Nitration & Amination
    (c) Oxidation & Polymerisation.

4. Comment on following explaining whether it is true or not :

1. In endothermic reaction heat-is given out and in exothermic reaction it is taken in.
2. Inert blanketing is required for toxic reaction.
3. Rota-meter is required to measure rotational speed.
4. Auto feed stop is an alternative to overflow pipe.
5. Dyke is not necessary for nitrogen storage tank.
6. Lightning arrester should be fitted just on the storage tank.
7. Manometer is used to measure vacuum in a reactor.
8. Flammable liquids are safe in plastic tanks.
9. Wooden crates are used to handle glass bottles.
10. Checklists are useful for inspection of a chemical factory.
11. Canister with face mask can be used inside .a "confined space" for protection against toxic vapours/fumes
12. Outlet valve of a dyke around storage tanks should be kept closed
13. Explosimeter used for measuring Hydrogen/ air mixture reads 20%. This indicates that there is 20% hydrogen in the sample.
14. Carbon monoxide arid Hydrogen cyanide are known as chemical as phyxiants.

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CHAPTER – 19

Hazards and Risks Identification, Assessment and Control Techniques

THEME

1. *Safety Appraisal, Analysis and Control Techniques :*
   - 1.1 *Objectives*
   - 1.2 *Safety Appraisal System*
   - 1.3 *Damage Control*
   - 1.4 *Total Loss Control (TLC)*
   - 1.5 *Job Safety Analysis (JSA)*
   - 1.6 *Safety Inventory System*
   - 1.7 *Product Safety*
   - 1.8 *Safety Work Permit.*
   - 1.9 *Safety Tag System*
   - 1.10 *Standard (Safe) Operating Procedure (SOP)*
   - 1.11 *Incident Recall Technique*
   - 1.12 *Critical Incident Review Technique*
   - 1.13 *Procedures Analysis*
   - 1.14 *Methodical Analysis*
   - 1.15 *Technique for Human Error Rate Prediction (THERP)*
   - 1.16 *PERT and CPM*
   - 1.17 *Safety Codes and Standards Including ISO 14001 & OHSAS 18001*
   - 1.18 *Safety Steward System*
   - 1.19 *Circuit Approach to Safety*
2. *Plant Safety Inspection :*
   - 2.1 *Definitions and Objectives*
   - 2.2 *Types and procedures*
   - 2.3 *Non Destructive Testing (NDT)*
   - 2.4 *Safety Checklists*
   - 2.5 *Safety Survey*
   - 2.6 *Safety Study*
   - 2.7 *Safety Tour*
   - 2.8 *Safety Review*
   - 2.9 *Safety Sampling*
   - 2.10 *Contact Scheme*
   - 2.11 *Good Manufacturing Practice (GMP)*
   - 2.12 *Recommendations & Follow-up Actions (Compliance)*
   - 2.13 *Responsibility for Inspections*
3. *Accident Investigation, Analysis and Reporting :*
   - 3.1 *Philosophy*
   - 3.2 *Purposes of Investigation and Report*
   - 3.3 *Process and Types of Investigation*
   - 3.4 *Agencies investigations Accidents*
   - 3.5 *Accident Analysis (Classification)*
   - 3.6 *Industrial Classification (NIC, 1987)*
   - 3.7 *Accident Investigation Report and its Content*
   - 3.8 *Methods of Collating and Tabulating Data*
   - 3.9 *Follow up for corrective action*
   - 3.10 *Record keeping*
4 *Hazard and Risk Assessment Techniques*
   - 4.1 *Hazards, Risks & Detection Techniques*
   - 4.2 *Hazard and Risk Progression Chart*
   - 4.3 *Risk Analysis, Assessment and Management*
   - 4.4 *Preliminary Hazard Analysis (PHA) & Hazard Analysis (HAZAN)*
   - 4.5 *Failure Mode and Effect Analysis (FMEA)*
   - 4.6 *Hazard and Operability (HAZOP) Study*
   - 4.7 *Hazard Ranking (DOW and MOND Index)*
   - 4.8 *Fault Tree Analysis (FTA)*
   - 4.9 *Event Tree Analysis (ETA)*
   - 4.10 *Accident or Cause Consequence Analysis*
   - 4.11 *Maximum Credible Accident Assessment (MCAA)*
   - 4.12 *Vulnerability Analysis*
   - 4.13 *"What if" Analysis*
5 *Reliability Engineering :*
   - 5.1 *Principles of Reliability Engineering*
   - 5.2 *Application of Reliability Engineering*
   - 5.3 *Concepts of Critical Equipment and Devices*
6. *Major Accident Hazard (MAH) Control :*
   - 6.1 *Concept of MAH*
   - 6.2 *Types and Consequence of MAH*
   - 6.3 *Criteria (Identification) for the Plant to be under MAH unit.*
   - 6.4 *Role of the Management*
   - 6.5 *Role of the Authorities*
   - 6.6 *Role of the Workers & Public*
   - 6.7 *Role of the Public*
   - 6.8 *Safety Report, Safety Audit Report & Risk Assessment Report*
7. *On-site and Off-site Emergency Plans :*
   - 7.1 *Need and Types of Emergency Plans*
   - 7.2 *Statutory Provisions*
   - 7.3 *On-site Emergency Plan*
   - 7.4 *Off-site Emergency Plan*

1 SAFETY APPRAISAL, ANALYSIS AND CONTROL TECHNIQUES

1.1 Objectives :

1 To appraise means to set a value on. Safety appraisal, therefore, includes all ways and means to measure and indicate the value of any plant, machinery, process, method, exposure etc. in terms of their individual and total safety effectiveness, performance, maintenance and control techniques. This is the first step of any safety organisation in its march toward accident or loss prevention programme.

2. Safety appraisal are of many types. :

(A) *Qualitative appraisal* is carried out to find the area where safety improvement is necessary. It includes techniques of inspection, audit, review, analysis, study etc. for the exclusive purpose of safety. Previous approval of plant and building, machinery layout, safety measures provided and to be provided are required under the Factories. Act and Rules for this objective.

(B) *Quantitative appraisal* is the method of computing accident frequency, severity, incidence and their index rate as we studied in Part 11.2 of Chapter-5. Frequency rate is useful in comparing safety performance of different units in a given time, while severity rate is useful in comparing safety performance of the same unit in different periods. Significance and utility of such injury rates are explained in details in Chapter-5.

(C) *Preventive appraisal* includes preventive maintenance before any accident occurs. Plant safety sampling, safety survey, faulttree analysis, risk analysis. HAZOP and HAZAN studies, safety inventory, system safety, safety standards, safety permit system, safety tag and lockout, safety steward etc. are used for this purpose. Inspections by the plant personnel. Safety Officer, safety expert and factory inspectors must be utilised for this objective.

(D) *Corrective appraisal* includes corrective maintenance after any accident takes place or any defect (crack, corrosion, wear & tear etc.) detected. If such damage/injury valuation and repairing is not carried out, it will continue the interruption of activity and ill-effect on health and safety. Accident investigation, analysis, identifying the key facts, accident potential and causes, application of the remedy (corrective action) are carried out for this objective.

3. Statutory appraisal tests and records are prescribed as a minimum- measure necessary. Testing of boilers, pressure vessels, lifting machinery, fire safety, monitoring and analysis of toxic, flammable, explosive or harmful environment and medical health check-ups .of workers are prescribed under the Factories Act and Rules. Water/Air Pollution Control Acts, Environment (Protection) Act & Rules and similar statutes are also for this objective.

4. Organised industrial safety is, now, recognised as an integral part of routine industrial operations. Inspections of plant, machinery, tools, equipment, premises, work practices, processes, procedures and general environment must be carried out for the health and safety of plant-people and surrounding. On-site and Offsite Emergency Plans are also useful in this regards.

5. To assess the overall standard of safety performance the concept of Safety Audit developed by Chemical Industries Association is also useful in non-chemical industry.

6. The concepts of Total Loss Control and Total Loss Prevention are also useful to measure and maintain the levels of safety.

7. As we have seen in Part 4 of Chapter-5, indirect cost of accident is more than the direct cost of compensation and medical expenses. Injured party can also sue the employer. Similarly compensation is also payable for breach of product safety. A manufacturer may be economically out due to such accident losses. Therefore he must seriously think to save such high costs and losses by adopting good safety appraisal systems.

1.2 Safety Appraisal System :

Safety appraisal system is a system, method, practice or procedure to measure the safety performance or standards for the purpose of evaluating its effectiveness and reliability, to find out drawbacks or deficiency if any and to suggest the safety measures to raise its safety value.

For this broad aspect, safety appraisal system includes many techniques of measurement and control. It is desirable to adopt it as a regular practice of plant safety inspection or safety auditing before any accident occurs. Measurement of injury frequency rate, severity rate, incidence rate, safety activity rate and total cost of accident is an quantitative appraisal system. The qualitative system includes statutory safety approval, inspection, checklists and follow up, design and construction safety, process & product safety, safety checks and standards, machine guarding, good house keeping and maintenance, chemical safety, engineering controls, use of safety devices and equipment, safety survey, safety sampling, hazard/risk detection, measurement, assessment and control techniques, safety study, safety tour .safety training, safety observation plan, damage or loss control, job safety analysis, critical incidence technique, fault tree analysis, HAZOP and HAZAN, safe inventory, system safety, circuit approach to safety, safety permit system, total loss control, safety stewardship scheme, plant safety inspection, checklist and audit, safely recommendations and compliance, accident investigation, fact finding, analysis, selection and application of remedy, report writing and maintaining good safety records to check safety performance at any time. On-site and Off-site emergency plans are useful to plan and handle emergencies and control major hazards. All factories should prepare their on-site emergency plans from their own resources. This will be useful to minimise heavy accidental losses. All these systems are explained below in brief :

1.3 Damage Control:

Damage means severity of injury or physical, functional or monetary loss that could result if control of a hazard is lost.

Damage Control is directly concerned with the protection of machinery, materials and manufactured goods assets from accidental loss within the factory. Indirectly it is concerned with money asset and manpower asset.

The Problem of Damage Accident was highlighted by H. W. Heinrich some 75 years ago. He analysed 75000 accidents and concluded that an accident can result in human injury and damage to property or both and the causes of injury and damage are similar - lack of skill, knowledge, unsafe system etc. Frank Bird (USA)'s study of 90,000 accidents in 1959 revealed that damage accidents were 5 times more frequent than injury accidents. He concluded that for 145 disabling injuries there were 15000 other injuries and 75000 property damage accidents. He carried out second study in 1966 of 17,53,498 accidents of 297 industries employing 17,50,000 workers. He concluded that 30.2 property damage accidents were reported for each disabling injury. He pointed out the ratio 1-100500 of disabling injury (1),to minor injuries (100),and incidents with no visible injury or damage (500). Similar other researches also conclude that damage accidents outnumber personal injuries and then account for greater loss then injury accidents. In spite of this fact/ is it not strange that safely programmes are more oriented to injury prevention than damage prevention?

Impediment to damage control was due to old definition of accident considering personal injury only, and referring property damage accident as ' no injury accident ' The modern definition_of accident is ' an unintended event that results in physical harm to a person or damage to property'. Un-r,eporting or underreporting of damage accidents, no statutory requirement (except dangerous occurrence) and failure to set up a realistic programme to damage control are other impediments.

Therefore damage control problem should be property recognised to prevent all accidents causing (a) damage to plant, machinery, equipment, tools, building and other property (b) loss of quantity or quality of materials during storage, handling and transport and (c) delay to process, function or activity due to need of repair or replacement.

Benefits of damage control scheme are :

1. Reduction in potential accidents and chance of injury accidents.
2. Reduction in severe injuries, production delay, and costs of maintenance, replacement and damaged materials.
3. Detection of unsafe conditions and unsafe actions which may contribute to injuries.
4. Increase of quality control, profit, importance and status of safety organisation, awareness of supervisors and management to control property damage.
5. Suggestion of remedial measures to prevent recurrence.

Steps to introduce good damage control programme are as follows :

1 **Spot checking :** Includes visiting repair centres, making observation and taking notes.

2 **Damage Reporting and Investigation :** All unplanned or unintended happenings likely to cause personal injury must be reported by workers and supervisors to management. Such cases should be property investigated and corrected.

3 **Damage Costing and Auditing :** Cost of repairs arising out of accidental damage must be marked by 'D', accounted for and their records must be maintained. A full time damage control inspector can audit all work orders, conduct regular inspections, spot checking of repair centres and analysing damage cost factors.

Computation of direct and indirect cost of damage accidents should be carried out as explained in Part 4 of Chapter-5. Another method is Ledger cost concept which is concerned with damage to machines, equipment, materials and loss of production time. Having worked out the damage cost for full year, the cost-severity rate can be evolved by the formula -

$$\text{Cost-severity Rate} = \frac{\text{Total cost of accidents} \times 10^6}{\text{Total production man-hours}}$$

This property damage severity rate can be compared from year to year.

4 **Remedial Engineering :** Collecting data of repetitive repairs to equipment and property from repair shop, redesign of equipment, revision of layout or work method and engineering controls should be implemented to prevent those damage accidents.

1.4 Total Loss Control (TLC)

The Concept clarified : The concept of Accident Prevention when applied to prevent human injuries only, it is called Injury Prevention or Control. When it is applied to control property (machinery, materials and manufactured goods) damage (losses) only, it is called Damage Control. When it is applied to control human injuries and property damage (losses) both, and also extended to include injuries and property damage to society or surrounding, it is called Total Loss Control (TLC), Total Accident Control (TAC) or Total Injury Control (TIC). When this concept of total loss control is applied or achieved by means of engineering controls, it is known as Total Loss Prevention (TLP).

The terms damage control, loss control, loss prevention and risk management are defined in Chapter-2 with other terms to realise the total concept of safety.

The concept of Total Loss Control is also defined as follows :

It is an evolution from injury prevention to .the control of all business losses by the application of sound management principles.

It is a system of reporting and controlling all incidents, however small, whether the associated loss is small or large. All incidents are examined, potential losses estimated and recommendations are made and acted upon to avoid repetitions.

It is a programme to eliminate unnecessary costs by means of identification of down grading situations, measurement of the loss potential, selection of methods to control the situation and finally implementation of the methods within the industrial enterprise. A down grading incident could be defined as any deviation in accepted performance levels resulting in injury, occupational sickness or disease, property damage, fire or explosion, breaches of security, pollution or product liability and business interruption.

Development of the Concept : Historically, the concept evolved from H. W. Heinrich's ratio in 1931 that for one serious injury there may be 29 minor injuries and 300 no-injury accidents (Ratio 1-29-300). Frank E Bird, after intensive research in 1966, gave this ratio as 1-100-500, John A. Fletcher, after a world-wide survey in 1969, gave this ratio as 1-19-175.

Though this ratio differs because of different study conditions, it proves two important conclusions: (1) No injury accidents are far greater than the serious or major injury and (2) It is necessary to control or prevent large number of no - injury and minor injury accidents for controlling or preventing a major or disabling accident.

Thus increasing hazards to persons and property because of the industrial revolution in western countries has developed this TLC concept and now, many books are available on this subject.

Relevance of Total Loss Control to India : This concept of TLC has great relevance to India as every loss reduced or eliminated would help to conserve our limited resources and control prices.

Some Annual Indices of avoidable losses in India are estimated below:

1. Accidental deaths in industries and elsewhere 1,40,000.
2. Non-fatal injuries in factories, 5,00,000.
3. Workmen Compensation being paid Rs. 500 lakhs.
4. ESIC benefits being paid Rs. 20000 lakhs.
5. Loss due to deficiencies in packing, transportation and storage of commodities like food, cement fertilisers etc. Rs. 5000 crores.
6. Losses due to fire Rs. 2000 Crores.

These figures reveal great opportunity to prevent as many losses as possible by our collective efforts.

The Fundamentals of Loss Control: Some fundamental principles are given below :

1. Accidents, unsafe conditions and unsafe actions are symptoms of something wrong in the management system.
2. Certain sets of circumstances can be predicted to produce sever injuries, which can be identified and controlled.
3. Safety should be managed like any other company function. Management must direct the safety efforts by setting achievable goals by planning, organising, and controlling to achieve them.
4. The key to effective line safety performance is management procedures that fix responsibility and accountability.
5. The function of safety is to locate and define the operational errors that allow accidents to occur.

The functions of safety -can be carried out in two ways :

1. By asking wily i.e. searching for root causes and
2. By asking whether or not certain known effective controls are being utilised.

Management for Loss Control : Risks Department, Risk Manager and Departmental Heads should, first, formulate Total Loss Control Policy for the company. Loss Prevention Committee should be formed to execute the policy. Responsibility should be fixed. By special attention to employees selection, placement, training and participation and adopting safety in design, safety audits and checklists, the goals should be achieved.

Four Steps procedure is necessary :

1. Identification of hazards.
2. Evaluation of hazards and their detailed analysis.
3. Planning and implementing measures to reduce hazards and
4. Frequent review.

Application of this procedure brings following benefits :

(a) Mi-nimismg damage to men, machines materials (raw and finished) and methods.
(b) Saving on insurance or better insurance cover at lower cost.

Control measures monitored by the Loss Control Department are:

1. Rules and Regulations.
2. Traffic Laws.

3. Standard Procedure Instructions.
4. Measurement of safety performance by various ratings (Indices).
5. Occupational safety and health standards/ rules.
6. Investigation of Losses and
7. Summary Analysis.

Thus by adopting Total Loss Control we can render the workplace fully safe and efficient.

1.5 Job Safety Analysis (JSA) :

Purpose & Definition : Job safety Analysis is a procedure of analysing job for the purpose of finding the hazards in each step and developing safety precautions to be adopted.

Though this technique tan be applied at any stage, it is most useful at the stage of planning, design and starting the process.

It can be used to review job method and uncover hazards (a) that may have been overlooked at the design or planning stage of plant layout, building, machinery, equipment, tool, workstations, processes etc. (b) that were noticed subsequently (c) that were resulted from changes in work procedure or personnel. It is the first step in hazard or accident analysis and safety training. .

It determines details of each job in terms of duties, skills, abilities, qualification, safety aspect, tools required, methods, sequence of operation and working condition. It is useful for routine or repetitive job as well as maintenance and short orders.

Advantages (Benefits)

1. It suggests what personal characteristics such as age, sex, qualification, skill, experience, abilities, physical standards etc. are necessary for selecting a right man for a right job.
2. The job breakdown sheets are useful to train new workers in proper sequence of doing the job safely and efficiently.
3. The hazards are noticed before they cause any accident.
4. It suggests preventive measures in advance to avoid accidents.
5. It helps for planned and effective safety inspection and accident investigation.
6. It suggests improved job methods, motions, positions, actions and work standards.
7. Proper organisation of methods consistent with accepted safe and efficient practices.
8. Preplanning, preparedness and propel performance can be started by executing properly the requirements of the operation.

Procedure : Four basic steps of simple procedure

1. Select the job.
2. Breakdown the job into successive steps.
3. Identify hazards and potential accidents in each step.
4. Develop safety measures to eliminate above hazards and consequential accidents. These steps are briefly explained below :

Jobs with potential for more frequent accidents, severe injuries and new jobs wherein hazards are unknown should be selected first.

The job should be broken down in proper sequence and steps. Operation, description, hazards (existing or potential) and precautions should be mentioned.

To identify hazards observe the operations as many times as necessary, ask the operator concerned or others having good knowledge of that job and list the hazards in each step. Consider all possibilities of accident, failure mode and effect etc.

The safely solution to the hazards noticed may be worked out by (a) finding a new method to do the job (b) changing the physical conditions creating hazards (c) eliminating hazards still present or changing the work procedure (d) reducing the need of doing that job or at least the frequency of the job and (e) suggesting personal protective equipment if any.

Everything of above findings should be recorded on Job Breakdown Sheet (Job sheet or Job instruction sheet) and it should be explained to operators and trainees to perform the job safely.

Job safety analysis should be carried out by a person well conversant with the job. The supervisor is well suited for this. Where safety officer is appointed he may carry out the analysis jointly with the supervisor.

Example:

The procedure of Job Safety Analysis is illustrated below.

In a factory rough castings of 15 Kg. are .fettled by hand on a pedestal grinder (dia 12"). The castings are picked up from nearby store, fettled on the grinder and replaced on the floor on the other side of the machine. Carry out job safety analysis and prepare the job breakdown sheet.

Job Breakdown Sheet			
Operation Step	**Description**	**Hazards**	**Precautions / controls**
1.	Start the job.	1. Breakage of wheel 2. Contact with wheel 3. Flying particles	1. Check and adjust the Guard 2. Adjust tool rest 3. Get wheel dressed if necessary 4. Use goggles/ shield
2.	Pick up the job.	1. Sharp edges 2. Unsafe gripping or lifting	1. Use hand gloves 2. Use Safety shoes 3. Proper method of storing 4. Proper training in lifting.
3.	Grind	1. Flying particles 2. Wheel breakage due to jamming etc. 3. Dust-Silicosis, nuisance	1. Use goggles shield 2. Do not jam 3. Local exhaust for machine and respirator 4. Aprons 5. Gloves
4.	Replace the job.	1. Sharp edges 2. Fall of casting 3. Strain and sprain	1. Use hand gloves 2. Use safety shoes 3. Proper method of storing 4. Proper training in lifting

Further details maybe written at the end of this sheet

1.6 Safety Inventory System :

This method proceeds to analyse quantity of hazardous material and to reduce it to the minimum possible level, to find out its safe substitute if any, and to find out necessary control measures to prevent or contain any accident due to it.

See Part 10.8 of Chapter-28 for MSIHC Rule; and Rule 681 of the Gujarat Factories Rules wherein threshold quantities of chemicals are stated in Schedule-2 and 3. In Sch-2 the quantity varies from 0.75 tonne (for Carbonyl chloride) to 15000 tonnes (for flammable liquids). In Sch-3 the quantities varies from 1 kg (for many chemicals) to 1250 tonnes (for Ammonium nitrate fertiliser) and 50000 tonnes (for flammable liquids). If the quantity exceeds this threshold limits, the unit is identified as MAH unit and specific safety rules are applicable. These rule; include disclosure of safety information, notification of major accident, notification of industrial activity, safety reports and on-site and off-site emergency plan. Thus inventory plays now statutory role also.

Threshold Quantities are listed for -

1. Toxic chemicals up to 1 kg.
2. Toxic chemicals > 1 kg and up to 200
3. Highly reactive substances 2t to 1250t.
4. Explosive substances 100 kg to 50t.
5. Flammable substances 15t to 50000t.

Steps suggested by the World Bank and IFC Guidelines to prevent major accident and to limit their consequences are: Proper design, construction, inspection, maintenance and operation of storage vessels and process plants, alarms, trips, dump-tanks, scrubbers, water curtains, emergency procedures; information, training and protective equipment to workers, and on-site and off-site emergency plans.

It is also suggested that within I km. radius of major hazard, no population should be allowed and within I to 2 km, limited development of low density such as warehouses and light industry may be allowed.

See Part 17 of Chapter-18 for some Committee Reports. ,

1.7 Product Safety :

It is a legal responsibility of every manufacturer seller, agent or supplier of each product to render it safe (non-injurious), otherwise if any harm is caused to a consumer, buyer, user by that product, legal damages are payable over and above any statutory compensation, for accidental injuries.

Section 7B of the Factories Act imposes duty upon every designer, manufacturer, importer or supplier of any article and substance for use in an) factory, to make that product safe and without risk; to the health of the workers, to carry out necessary test for this purpose and to supply safety information regarding safe use of that product The product should conform to the Indian and Foreign (higher) standards.

Negligence or Breach of Warranty should be proved to establish product liability.

The manufacturer is obliged to (1) exercise care in planning, designing and producing his product, reasonably safe for all users and (2) provide adequate warning and precautions with the product for the safe use.

Breach of warranty may be expressed (written) or implied (oral). Advertising and sales literature also amount to warrantees to the ultimate consumer and any remote consumer can recover damages for breach of these warrantees. Product liability cases involve heavy direct and indirect costs.

In USA, National Commission on Product Safety estimate that more than 20 million are injured and 30,000 deaths per year due to products. This lead to the enactment of Consumer Product Safety Act there. The Consumer Protection Act has also been enacted in our country and Consumers' Councils and Courts work at many places where complaints regarding 'product' can be launched.

Product safety programme should include clear policy, duties and responsibilities of personnel in design, manufacturing, quality control, marketing and servicing. The committee should include Chief Engineer, Sales Manager, Service Manager and representatives from other departments. The committee shall carry out various functions such as review of design, change required, safety warning signs and warnings, review of accidents and claims and education of engineers and operators.

1.8 Safety Work Permit:

Objects and Types : Some jobs in a factory are dangerous to life and therefore well advanced precautions arc necessary before their commencement and till the completion. Hot work like welding and cutting, entering any confined vessel, working at height or on fragile roof, opening of dangerous pipelines, electric work and handling dangerous chemicals etc. are some example. For the safety from such works, a work permit system is highly essential.

Work permit system requires that authorisation be issued and obtained before any work is performed on process. Equipment or area and instruction contained therein must be strictly followed by the permitted workers till the time limits.

A work permit system should cover the following points

1. Who requires a work permit, e.g. contractors, engineers, maintenance workers, etc.
2. What jobs require a work permit, e.g. all maintenance work, tank cleaning, electrical inspections, etc.
3. What types of permit are available :

General work permit	For work of a non-hazardous or 'cold' work type.
Special work permit	For work on live equipment, or hot work.
Confined spaced entry permit	For work involving entry into confined spaces such as tanks, sewers, excavations where toxic or flammable vapours may be present.
Gas Test Certificate	This may form part of the above permits and specifies what gas tests are necessary at particular periods.
Electrical Isolation Certificate	Specifies what electrical isolations are required and whether locks, earths, notices are to be applied.
There are will be occasions when the work to be done requires all the above permits and certificates to be issued.	

4. Who is responsible for issuing work permits a list should be compiled by management authorising specific persons to be responsible.
5. Arrangements for recording the issue, revalidation and retention periods of permits.

Most Commonly used permits are fire or hot work permit, safe (vessel) entry permit, excavation permit, electrical work permit, chemical area work permit, high height or depth permit and so on.

Who Issues and to Whom : Work permit is issued by supervisor, safety officer or responsible officer of the area and equipment. It is generally issued in the name of a supervisor or technician who has to carry out the required job under his direct supervision.

Contents of the permit : Some contents may very according to the permit but generally the contents are : Name of the supervisor or person to whom it is issued, workplace, equipment, name of the work to be carried out, date and time of start and completion, personnel permitted, details of actions, conditions, equipment, procedure and precautions from the authority who issues it.

The elements of a permit to work system are :

1. Hazards of the plant, chemicals and work are fully explained to the workers involved.
2. Instructions are in details and fully understood by both the parties.
3. Work area should be clearly identified, made safe or the hazards highlighted.
4. In-charge of the area who issues the permit, should be competent and responsible and should sign the document stating that he is satisfied regarding necessary isolation, blanketing etc. completed and it is made safe for the workers to work in that area.
5. The in-charge of the team of workers, who receives the permit must sign the permit stating that he has fully understood the work to be carried out, the hazards potential, precautions, conditions and procedure and the PPE/FFE to be utilized.
6. Any monitoring including gas testing required before, during and after the work should be specified and the results noted on the document.
7. When the work is completed (after necessary extension of the permit if work continues), the work in-charge signs off the permit stating that the specified work has been completed and the plant is in a suitable state to return to operations.
8. The area in-charge signs to accept that the work has been completed and he now accepts the responsibility.

Formats : A format can be designed according to the work but it should cover above mentioned eight points. More care is required when the permit is to be given to a contractor's workers. Necessary equipment must be supplied to them. Some formats are given in Table 19.1 to 19.3.

Table 19.1 : **General Format : Safety Work Permit**

Permit to work	Name & Address of the Factory :	Permit No. ___________ Date :
Date & Time of Issue ________________________ Date & Time of Extension if any ________________________ Date & Time of Validity ________________________ Date & Time of Work Completion and Return of the Permit ________________________		
A. Issue 1. Location of work		

2. Work to be done 3. Hazards involved 4. Precautions / conditions necessary 5. Equipment to be used 6. Procedure to be followed 7. Special instructions 8. Prior work done and certified. Necessary isolation, cleaning, purging and testing/ monitoring is done and reported below with results :			
Name & Designation of the Area-in-charge	Signature Date Time	Validity Date Time	Ratification by the Safety Department
B. Acceptance I have read and understood this permit and will carry out the work as per directions stated above.			
Name & Designation of the Area-in-charge	Signature Date Time	Validity Date Time	Ratification by the Safety Department
C. Acceptance I have re-examined the situation above and hereby extend this permit to expire at Date _______________ Time _______________ Further instructions if any : Signature Date Time			
D. Completion and Cancellation I certify that the work is completed and the plant can be put to its normal operation. Signature Date Time (By the person who accepted the permit) I accept the above plant back into service. The permit is cancelled hereby. A new permit will be required if work is to be done again. Signature Date Time (By the person who accepted the permit)			

N.B. : Detailed instructions shall be written in this document. Where possible. Part A shall be- ratified by the Safety Department.

Table 19.2 : General Format : Safety Work Permit

Permit to Work

Permit No.______
Date:

Procedure used shall be in accordance with safety instructions
(Give consideration to each word. Strike out those not applicable)

Name & Address of the Factory :
Plant___________ Section/Equipment ________ Valid Until Date _______ Time :_____Hrs.____

PART - A ; Preparation________

A-l Following Hazards are possible.
☐ Gas/Fume
☐ Corrosive, Hot & other Liquid
☐ Gas or liquid under Pressure
☐ Toxic Materials
☐ Dust
☐ Fire & Explosion
☐ Hot Metal
☐ Trace Heating
☐ Steam Condensate
☐ Falling Objects
☐ Electricity Mains/Static Electricity/Shock
☐ Moving Machinery
☐ Overhead Hazards, Cranes etc.
☐ Underground Service
☐ Traffic (Road & Rail)
☐ Radio active substances
☐ Noise
☐ Work at
☐ Height
☐ Other (Specify)

A-2 Physical Isolation
☐ Physical isolation is required/not required
The Equipment isolation permit No. ______________________________
Method of Isolation
☐ Single/Double isolation, valve closed/blind/tagged (no.
☐ Lines slip plated
☐ Physical disconnection : open and blanked off
☐ Vent. Drain or blow off open

A-3 Precautions already taken : ____
____

☐ A-4 Hotwork Permit:
A hotwork permit is not necessary.
A hotwork permit is necessary, permit issued no.
A-5 Vessel Entry Permit :
☐ A vessel entry permit is not necessary
A vessel entry permit is necessary, permit issued no.

A-6 Installed Radioactive Source:
☐ There is no installed radioactive source
☐ There is an installed radioactive .source and is made safe
I have made the installation sate for the duration of tills Permit By

Signature of Qualified person

A-7 Electrical Isolation:
☐ Electrical isolation is not required
Electrical isolation is required and has been made by following methods and tagged (Tag No.)
☐ Fuse withdrawn
☐ Drive Unit Disconnected / Denergised
☐ Racked out
☐ Locked out Name___________ Signed _________________

A-8 Other (e.g. Instrument, Cathodic Protection)
Isolation not required
Isolation required and has been done (Tag. No. ____________)
by (Name) ____________________ Signed _________________________
A-9 Preparation Completed:
Name Designation Signature

PART - B : Operation

B- 1 Job to be done

____
____
____
____
____
____

B-2 Precautions to be taken.

☐ Wear PVC suit
☐ Use self breathing apparatus
☐ Wear PVC, Rubber, Leather, Asbestos etc. gloves
☐ Use air line respirator
☐ Wear Ear Muff/Plugs
☐ Wear a safety belt with life line
☐ Wear Helmet
☐ Keep fire extinguisher ready
☐ Wear Full face shield
☐ Keep rescuer available
☐ Wear Goggles
☐ Use only safety torch/hand lamp
☐ Use Gas Mask for___________(gas)
☐ Use only 24 Volts inspection lamp
☐ Use Dust mask
☐ Use ELCB

B-3 Removal of Equipment
☐ Removal of equipment from the site is not required
☐ Removal of die equipment from the site is required
☐ The equipment is cleaned

☐ The equipment is not clean. Take following precautions

B- 4 Special instruction

____
____
____

PART - C : Issue, Acceptance & Return

C-l Issue and Acceptance

	Name	Signature	Date and Time
Issued by	____________	____________	__________
I have read the conditions of this permit			
Accepted by	____________	____________	__________

C-2 Extension of Validity (Please sec on the back)

C-3 Text/Rotation check required

Signature of person making request ____________________________________

Electricity restored by ____________________ Sign. _____________________

Test run Completed/Rotation check correct Sign _________________________

Electricity isolated by ______________________ Sign. ________________________

C-4 Completion of job

This job is completed :The job site is cleaned and material removed.

Returned by Name & Sign ________________________ Time and Date _____________

C-5 In case of hot work permit/vessel entry permit.

The Hotwork permit No. _________________ is cancelled

The Vessel entry permit No.______________is cancelled

Countersigning person have been informed

Sign. __________________Name ____

C-6 Cancellation

This permit is cancelled. Please restore electricity. Remove or restore radioactive source/others

Name ______________________ Sign ______________ Date & Time ______________

C-7 Installed radioactive sources

I have recommissioned the installation

Signature of qualified person_______________________________________

C-8 Electricity Restored

☐ Fuse replaced ☐ Racked in

☐ Drive unit reconnected ☐ Lock removed

Signature ______________ Name ____

C-9 Other isolation (Specify) ____

Restored by ____

Sign______________ Name ____

C-10 Details of job done

____
____
____
____

(back page) Instructions (See Part C2)

1. The Permit to Work does not ensure that the job is safe but it tells you the exact state of the job, precautions already taken, precautions to be taken by the permittee and residual hazards associated with the job Therefore the issuing authority must give consideration to each point/word and strikeout which is not applicable or marked D in the appropriate box. The permittee must read the contents of the permit carefully and follow the instructions and precautions to be taken.

2. In case of any emergency in the plant, the job shall be stopped and the permit shall be treated as cancelled. The work can be restarted after the emergency is over but the permit to work shall be endorsed by the issuing authority before starting the work.

Extension of Validity

C-2 The job is not yet completed. Therefore this permit requires extension of validity.

Extension of validity requested by		Time & Date up to which the Validity is requested		Reasons for requesting Extension	The permit is extended i.e. revalidated UPTO :			
Name	Signature	Time	Date		Time	Date	Name	Signature

Table 19.3 : Hot Work Permit

Name & Address of the Factory	HOT WORK PERMIT	Permit No. : Date :

A. Job Details :
Requested by ______________________ Dept./Plant ____________ Section ________________
Validity Date _____________________________ Time : From ______ Hrs. To _________ Hrs.
Location Details ____
Description of Work : ____

____

B. Precautions : Tick (✓) in the relevant boxes where applicable and score out the others.

Already taken by operators	To be taken by Maintenance

☐ Equipment has been properly – Tick (✓) in the box (a) depressurized ☐ (b) Drained ☐ (c) Washed ☐ (d) Vented ☐ (e) Purged ☐ (f) Steamed ☐ (g) gas freed ☐ (h) isolated ☐ (i) blinded ☐ ☐ Surrounding area checked and protected against hazards of spark / fire. ☐ Sewer openings covered /protected. ☐ Frequent explosimeter monitoring required during continuation of job. ☐ Keep fire station informed. ☐ Standby man available for rescue. ☐ (others) ________________________	☐ Sparks can ignite the material in the surrounding areas. Effects protect process sewers / material / equipment in the vicinity from a potential fire hazard. Keep the area wet. ☐Properly ground the equipment and use insulated welding cable. ☐ Keep escape route clear. ☐ Keep fire extinguisher ready. ☐ Keep fire hose connected with nozzle for use (not charged) ☐ Use only fir proof gloves /suits. ☐ Make provision to contain the sparks by shielding the job location from all sides using fire blankets.

C. **Initial Explosimeter Test :** (Indicate the exact locations where the tests are carried out)

Sr. No.	Location	Explosimeter (LEL) reading	Date	Time	Name	Signature

D. **Authorisation :**

Shri _________________________of Dept. : _____________ Section ___________ is hereby given permission to carry out the above work. This permit expires at _____ hrs. on ______ unless extended, [see (E) below]. Signature of issuing authority_________________ Date : __________ Time : ______Hr. Approved by : _____________ Signature ______________ Date : ____________ Time : _________Hr. Signature of accepting authority ____________________Date : ___________Time : ___________Hr.

E. **Extention of Validity** (To be renewed after every shift, maximum validity 24 hrs.)

(I) Condition at the site checked and found OK. The Explosimeter reading _____%LEL Time : ________ hr.
The validity of the above permit extended up to : _____ hr. on _____________ (date). Signature (Shift-In-Charge) _______________ Time : _________: hr. Date : ___________
Approved by: Signature:

(II) Condition at the site checked and found OK. The Explosimeter reading ____%LEL Time : ______ hr.
The validity of the above permit extended up to : _____ hr. on _____________ (date). Signature (Shift-In-Charge) _______________ Time : ___________ hr. Date : ___________
Approved by: Signature:

F. **Work Completion** (By the Maintenance Group) :
The work is completed. Area cleaned up. The permit returned to the issuing authority at _____hr, Date _______ Name: Signature : _____________________

G. **Job Acceptance :** (By Issuing Dept.) - The job has been completed and the work area has been restored in its original condition. Hence, the permit is hereby cancelled.

Name : Signature Time : ____ hr. Date :

The format of the permit to work should be designed by the safety officer, safety consultant or an experienced engineer of the company. Well thought precautions and safety measures can certainly minimise the accidents.

Vessel Entry Permit : Under section 36 (2) of the Factories Act 1948, no person in any factory shall be required or allowed to enter any confined space (chamber, tank, vat, pit, pipe, flue etc. having dangerous fumes likely to involve risk) until all practicable measures have been taken to remove any fumes which may be present and to prevent any ingress of fumes and unless a certificate in writing has been given by a competent person based on a test carried out by himself that the space is free from dangerous fumes and fit for persons to enter or such person is wearing suitable breathing apparatus and a safety belt securely attached to a rope (life line) die free end of which is held by a person outside the confined space.

Isolation of the vessel from sources of energy or harmful substance by way of cooling, disconnection, blinding, blanking etc., draining, cleaning, washing and purging to make free from toxic gases, testing the air for oxygen or toxicity content, opening top and bottom connections for good ventilation, lighting and exit, wearing safety belts, helmet and suitable breathing equipment, allowing low voltage (24 volts) light, standby arrangement etc. are essential requirements.

See Part 2.2 of Chapter 16 and Part 16.2 of Chapter-18 for safe entry procedure to confined spaces.

Hot work Permit : For welding and cutting, working with open flames or sparks due to grinding, chiselling etc. or where hot work is dangerous or may cause fire. Hot work or Fire Permit is necessary.

The area must, first, be made free from hazards of fire and explosion. Tests for explosive air mixture or possibility should be carried out. All lines to the vessel shall be blinded or' disconnected. Sufficient vents and flameproof light shall be provided. Fire protection and alarm shall be kept ready. Dangerous work shall not be allowed in the vicinity. Water facility shall be used to extinguish sparks, hot slugs etc.

See Table 19.3 for a Hot Work Permit.

Electrical Work Permit : The model form of permit-to-work is given in IS:5216 (Part-1).

Department of power generation, distribution, control etc. issues permit in the name of Electrical Engineer/Supervisor in charge of the job to be attended.

Before issuing permit it is ensured that the apparatus concerned is made dead, earthed and isolated from all live conductor by opening all relevant switches, circuit breakers, fuses, isolators etc. He who receives the permit, also rechecks to ensure that there is no possibility of accidental power supply. Then only he starts the work. In case when the work is continued in the next shift, the permit is transferred in the name of another person continuing the job. On completion of the job and before returning the permit for cancellation, it is verified that all persons on the apparatus are withdrawn, and temporary earth connections are removed. The permit issuing authority rechecks the apparatus, cancels the permit and energises the apparatus by closing all switches, fuses, breakers, isolators etc.

Similarly Work Permits can be prepared for other types of hazardous work keeping their special precautions in mind.

It is advisable to use separate permits for separate works instead of using a common (multiple) form for different works.

All contractors and company staff such as engineers and maintenance workers must be in possession of a valid work permit before they start any job at a company site. In some instances, operating staff must also have a valid work permit for operating jobs which may have a hazardous content such as opening a pressurised system, such as a product filter, pipeline, removing pyrophoric catalyst, working at height etc.

See also Parts 16 of Chapter-18 for further details of work permit system.

1.9 Safety Tag System :

IS:8095 provides specification for accident prevention tags. The tags are used as a temporary means of warning employees of an existing hazard or to warn them not to start any switch or operation, because some other person may be injured due to that. For example, while working in any movable or rotational machine, tag on isolated switch is necessary. To prevent wrong operation of any switch, valve, control etc., tagging is essential during repair. It is more useful for new or untrained workers. They should not be used in place of or as substitute for accident prevention signs. The tag shall be removed as soon as die hazard is removed or eliminated. 'Do Not Start' tag on power machine should be provided till the repairing is over and then it should be removed. Defective equipment tag shall be placed till die defect exists only. Accident prevention signs are of permanent nature, while the tags are temporary. For safety signs and colours see IS:9457.

The tag should be in the language understood by the workers.

Type of tags arc : Do not start tags. Danger tags. Radiation tags. Biological Hazard tags etc. Colours for some tags are prescribed but not the size which should be suitable .

1.10 Standard (Safe) Operating Procedures (SOP)

Hazardous works or frequently required jobs need standard and safe operating procedures. If they are well defined and described beforehand and available in the form of ready made document, they are most useful to plant people for easy use. Such procedures are useful in avoiding and reducing accidents.

Meaning and usefulness:

A Standard Operating Procedure (SOP) is a set of written instructions describing steps of safe working method and standard engineering practice for hazardous job or frequently required industrial activity.

It describes technical as well as administrative operating instructions from the management. It is designed by duly qualified and well experienced technical persons in the plant. It should be amended and updated based on experience of its use. SOP standardizes work procedure and avoids variations among different workers. It establishes uniformity and safety in working methods. It ensures that the same work is done in the same way by all workers safely and efficiently.

SOP should be written correctly. Steps should be chronological. If not written correctly, it is of limited value. The best written SOP may fail if not followed. Copies of SOP should be ready available in work areas so that they can be readily used. SOPs are useful to prevent shortcuts, wrong habits and unsafe practices.

Format for SOP :

SOP should be written in a well designed format. It should be easy to understand. It should clarify its purpose, method of use, tools, equipment and PPE necessary, work permit to be used if any etc. Steps and sub steps should be well arranged. SOP should have title, Sr. or Id. No., Date of preparation. Date and number of revision, steps and procedure, action by whom and remarks.

Some example of SOP are as under :

1. Nitrogen purging in a reactor.
2. Loading and unloading of tanker of hazardous substance.
3. Safe starting or closing down of a plant.
4. Catalyst loading into a reactor.
5. Flue or toxic gas sampling procedure.

SOP should get approval from the top management including safety department. It should be reviewed and revised. Checklist can be used to prepare SOP.

1.11 Incident Recall Technique :

This method is based on collecting information on hazards, near-misses, unsafe conditions and unsafe actions from working people. It can be used to investigate man-machine relationship and to improve equipment and operations. The technique consists of interviewing personnel regarding involvement in accidents or near-misses, errors, mistakes, difficulties and conditions which may cause accident. It accomplishes the same result as an accident investigation. Even isolated incidents reported by the technique can be investigated to determine whether corrective action is necessary or advantageous.

Plant people should be given accident case studies for reading and thinking. Then their memory should be recalled to know their understanding and further suggestions if any.

1.12 Critical Incident Review Technique:

The Critical Incident Technique by W.E. Tarrants, is a method of identifying or reviewing potential accident causes by collecting information on unsafe conditions and actions, near-misses, hazards etc. from experienced plant personnel. It can be used to study man-machine operational relationship and to use the information to improve equipment, operations and procedures.

An' experienced reviewer or surveyor first explains to key personnel what he wants to know. Then he asks each worker individually questions on safety matters. Workers' involvement in accidents, near misses, mistakes, errors, difficulties in performance and probable causes of accidents are thoroughly discussed. Their comments including preventive measures are also asked.

It has been estimated that for every mishap there are at least 400 near-misses. Information on possible accident causes can be obtained from participants of accidents and non-participants but having knowledge.

When interviews report similar difficulties, hazards or near misses with similar types of operation or equipment, it indicates an area to be investigated and results of investigation can suggest the remedial measures necessary.

1.13 Procedures Analysis :

This method reviews the possibilities of accidents due to actions of workpeople. First of all it checks whether the work method is hazardous or not. It ensures that the man-machine motion does not endanger the operator in following the method suggested by the designer or supplier.

A procedure is a set of instructions for sequenced actions to conduct operation, maintenance, repair, assembly, test, calibration, transportation, handling, emplacement, removal etc.

Procedure analysis is a review of the actions that must be performed for intended tasks, the equipment that must be operated or used and the environment in which personnel must work. Analysis ensures that the procedures are not only effective but also safe. Hazardous tasks like welding, tank entry etc. must be analysed in detail.

Procedure analysis sheet contains five columns : Task, danger, effect, cause and corrective or preventive measures. The procedure suggested should contain preparatory instructions, operating instructions, warning and precautions, checks and tests, step-by-step instructions to perform operation, stopping instructions and emergency instructions.

1.14 Methodical Analysis :

In the beginning of 20th century, Gilbreths suggested an orderly examination of an operation from its first step to the last, tracking the flow of work as it progresses. Symbols were used to draw a network diagram. Gilbreth's objective was to improve the work method by eliminating unwanted steps or re-planning the work so as to conserve time and effort. Safety in itself was not a consideration (Ref. No. 32).

This methodical analysis was the first of the analytical techniques to draw attention of the safety specialist. It was employed, subsequently with some modification, to assist in hazard control in manufacturing and as a basis for hazard identification and analysis.

1.15 Technique for Human Error Rate Prediction (THERP) :

Human Error Analysis identifies potential human errors and their effects or identifies the cause of observed human errors.

The Sandia Corporation developed a method to quantify the likelihood of employee error in manufacturing operations with the objective of reducing defects (Ref. No. 32).

The method is based on the principle that non-repetitive or infrequent actions may be difficult or impossible to predict, but the repetitive actions can be studied to determine human error probability data.

THERP establishes a basic error rate (BER) for selected tasks employing statistical methods to identify valid human error rates in performing the task. The BER unit is error per million operations.

Such data of human failure rates is interesting to safety specialists. It is useful for fault tree analysis discussed in Part 4.8. The data is mean average and may not be applicable to a particular operator. Skilled operators may commit less errors.

1.16 PERT and CPM :

PERT means programme evaluation review technique and CPM means critical path method. The first method was developed by US Navy for its Polaris Weapons Systems in 1958 and at the same time the second method was developed by the Du Pont Company (Ref. No. 32)

PERT and CPM generally deal with planning, scheduling and logistical problems involving the availability of materials, equipment etc. at appointed times and places for the process to flow expeditiously to completion. Safety is not their main objective, but it can be used for safety purpose.

In its modified form to include safety, PERT and CPM can be directed to (1) arrange activities so as to minimise the possible bottlenecks and total time (2) obtain an estimate of total time required to facilitate personnel and material planning to foresee the probable impact on delivery dates to customers and (3) foresee any possible hazards and take steps in the planning so as to eliminate or minimise them.

1.17 Safety Codes and Standards :

Codes of practice and standards are normally derived by experienced professionals and their organisations. Codes and standards transmit experience of problems and solutions and develop good industrial or engineering practice.

With change in technology and new inventions, revision becomes necessary. Thus codes and standards should be updated with the current time.

Standards and Codes should be followed in following order:

1. Statutory Standards.
2. Indians Standards (IS) and Codes.
3. International Standards like ISO 9001 & 14001 and OHSAS 18001.

(1) Statutory Standards.

Enacted Safety and other Acts, Rules and Regulations are mandatory or statutory and require legal compliance, failing which legal action may be instituted. Tlie Factories Act 1948 and Rules made there under prescribe standards for ventilation, artificial humid ification, workspace, lighting, drinking water, latrines, urinals and spittoons, lifting and revolving machines, pressure plants, excessive weights, protection of eyes, precautions in case of fire, toxic exposure, safety of buildings and machinery and welfare facilities. Factory Inspectors are also appointed to check these standards. It is also a statutory duty of Safety Officers where they arc legally required.

(2) Indians Standards (IS) and Codes.

If Statutory Standards are not available or if required as additional need, Indian Standards should be followed. They provide number of Safety & Product Quality standards. ICI marks are considered as good standards and they raise sale values. It assures good safety precautions. Indian Standards for safety and health, pressure vessels, chemicals, gas works etc. are of prime importance and used by good designers.

Codes are made from the groups of Indian or International Standards pertaining to particular subjects. Vizs. National Building Code, National Electric Code, National Fire Protection Association (NFPA) Code, American Society of Mechanical Engineers (ASME) Code etc.

Some are voluntary standards which may be followed for safe practices. Standards are often used for design, testing, certification and approval. Standards may be changed by time due to new knowledge or experience. Standards and Codes can be used as basis on which checklists can be prepared by which the plant's facilities, equipment and operations can be analysed or audited for hazards.

It should also be noted that standards or codes may be lacking in requirements or the requirements may not be stringent enough for actual conditions or they may not be applicable. Therefore blind observance of standards is not justifiable. Each hazardous situation must be examined and analysed-critically for full-proof safety.

(3) International Standards

After compliance of Statutory Standards and Indian Standards, International Standards should be followed.

Two standards are important for safety of environment and safety from occupational health hazards. They are as under :

(A) Environment Management 'System (EMS) ISO 14000 and Standard ISO 14001.

Environment is the basic requirement for survival and sustaining life on earth. We have been blessed environment from our forefathers and it provides us an opportunity to live long and happily. It is the duty of all of us to protect the quality of this environment and add our contribution so as to leave a better environment-and adequate resources for our posterity.

Developments in Science & Technology have added greatly to the longevity and quality of human life. These developments have sometimes had flip sides manifesting most notably in adverse impacts on the environment.

All organizations should have concerned with the protection, promotion and preservation of environment. Throughout the world, the government, organizations, firms and individuals are now increasingly concerned for the promotion of environment and prevention of pollution. All the employees of organization, shall contribute in the conservation of resources; prevention of pollution and promotion of environment.

It is recommended to implement ISO 14001 Environment Management Systems (EMS) Standard and request that there shall be no compromise in any manner which affects the environment at the site and this shall be ensured through strict adherence to environmental regulations and environment management system procedures; raising awareness on environment among employees; the contractors/ personnel working at the site and sharing our knowledge with the surrounding public.

The relations between men, flora, fauna, water, land and air are non-separable and these relations require to be maintained without affecting the equilibrium which the Nature has given us the day life began on earth.

All of us shall explore opportunities for the minimization of waste; and shall endeavour to minimize environmental aspects and impacts arising out of our operations. We shall ensure that there is zero material waste; full utilization of resources. We shall protect the plants; animals; birds at our site and shall not cause any harm to them and our fellow employees.

Advantages of EMS - ISO 14000 :

1. HSE Systems get further strengthened.
2. Fulfillment of national and international HSE requirements, particularly w.r.t. Occupational Health and Industrial Hygiene.
3. Complying local legal requirements and new norms w.r.t. Environmental Protection published by Government from time to time.
4. Employees' motivation and proud place in industrial society.

What is ISO - 14000?

1. ISO - 14000 is a series of voluntary international standard covering environmental management tools and systems developed by the International Organization for Standardization.
2. Intent to provide all industries - whether in manufacturing or service -with a structure for Environmental Management System.

What is ISO - 14001?

1. It is the standard a company will use to establish its Environmental Management System.
2. It provides frame works for environmental .management and integrates that frame work with overall business management activity.
3. It is a specification for Environmental Management System for ensuring and demonstrating compliance with stated Environmental Policy and Objectives of the Organization

Definitions:

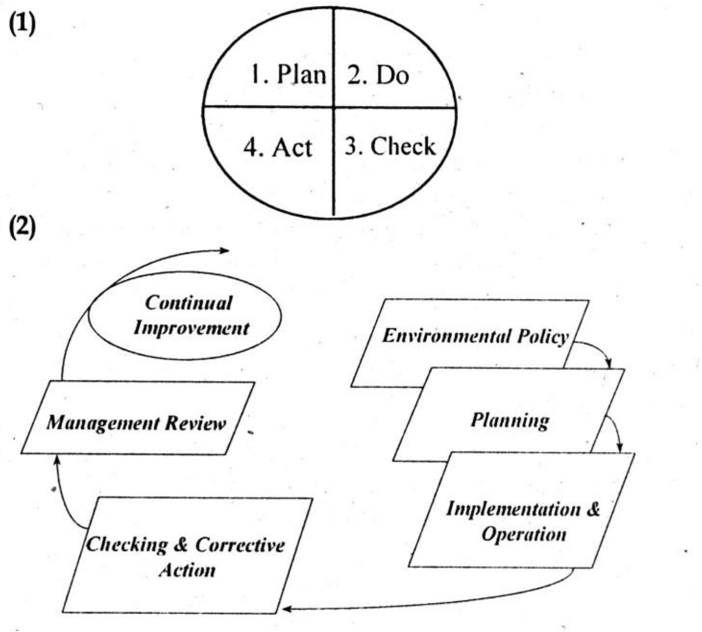
1. Environment - Surrounding in which an organization operates including air, water, land, natural resources, flora, fauna, humans and their interrelation.
2. Environmental Management System - The part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, process and resources for developing, implementing, achieving, reviewing and maintaining environmental policy.
3. Environmental Aspect - Element of an organization's activities, products or services that can interact with the environment.
4. Environmental Impact - Any changes to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.

Elements of ISO - 14001

1. General Requirements
2. Environmental Policy
3. Planning
   (1) Environmental Aspects
   (2) Legal & Other Requirements
   (3) Objectives & Targets
   (4) Environmental Management Program
4. Implementation & Operation
   (1) Structure & Responsibility
   (2) Training, Awareness and Competence

(3) Communication
(4) Environmental Management System Documentation
(5) Document Control
(6) Operational Control
(7) Emergency Preparedness and Response.

Environmental Management System Model



For details see website : www.isol4000- isol4001-environmental-mariagement.com

(B) Occupational Health and Safety Management System 18000 and Standard 18001.

Occupational Health and Safety Assessment Specification (OHSAS) is an international standard defining requirements related to health and safety management systems, enabling organization to manage both their operational risks and improve their performance. .It was developed in 1999.

More and more organizations are increasingly concerned about achieving and demonstrating sound Occupational Health & Safety performance to their customers, employees and shareholders, by managing the risks and improving the beneficial effects of their activities, products and services.

This Occupational Health and Safety Assessment Series (OHSAS) specification gives requirements for an occupational health and safety (OH&S) management system, to enable an organization to control its OH&S risks and improve its performance. It does not state specific OH&S performance criteria, nor does it give detailed specifications for the design of a management system.

This OHSAS specification is applicable to any organization that wishes to:

1. establish an OH&S management system to eliminate or minimize risk to employees and other interested parties who may be exposed to OH&S risks associated with its activities;
2. implement, maintain and continually improve an OH&S management system;
3. assure itself of its conformance with its stated OH&S policy;
4. demonstrate such conformance to others;
5. seek certification/registration of its OH&S management system by an external organization; or

6. make a self-determination and declaration of conformance with this- OHSAS specification.

All the requirements in this OHSAS specification are intended to be incorporated into any OH&S management system. The extent of the application will depend on such factors as the OH&S policy of the- organization, the nature of its activities and the risks and complexity of its operations.

This OHSAS specification is intended to address occupational health and safety rather than product and services safety.

The organization shall establish and maintain an OH&S management system, the requirements for which are set out in clauses.

Advantages of OHSAS 18001 Accreditation.

1. HSE Systems get further strengthened.
2. Fulfilment of national and international HSE requirements, particularly with respect to Occupational Health and Industrial Hygiene.
3. Complying local legal requirements and new norms with respect to Occupational Health, Environmental Protection and Safety as published by Government from time to time.
4. Employees' motivation and proud place in industrial society.

What is OHSAS 18000?

It is an Occupational Health and Safety Management System or Series which provides a framework for managing OHS responsibilities. The framework is designed to allow companies to become more efficient and operate in a more integrated manner.

Specifically, OHS management systems specify a process of achieving continuously improved OHS performance and complying with legislation.

What is OHSAS 18001 ?

OHSAS 18001- 'Occupational Health and Safety Management Specification or Standard' is an international health and safety management system specification, embracing BS 8800, AS/NZ 4801, NSAI SR 320 and other publications. It is under OHSAS 18000.

OHSAS 18001 has been developed to be compatible with the ISO 9001 (Quality) and ISO 14001 (Environmental) management systems standards.

What is OHSAS 18002?

To compliment OHSAS 18001, the British Standards Institute published OHSAS 18002'Occupational Health and Safety Management Systems Guidelines' to assist in the implementation of OHSAS 18001.

This explains the requirements of the specification and shows companies how to work towards implementation and registration.

By adopting this package, it will allow companies to :

1. Identify elements of business that impact on health and safety and gain access to the relevant legislation.
2. Produce objectives for improvement and a management program to achieve them, with regular reviews for continual improvement.
3. BSI Management Systems will periodically assess the system and, if complied, register your company or site to OHSAS 18001.

How does it work ?

The OHSAS 18001 Specification follows the Plan-Do-Check-Review cycle, with an emphasis on continual improvement. Registration can be obtained.

For details see website : www.ohsas-18001occupational-health-and-safety.com

1.18 Safety Steward System :

Safety Steward or Monitor system is an old concept of deputing one supervisor or a senior man for overall safety supervision in a plant. The steward or monitor will take rounds of the plant, premises, processes and persons assigned to him and will observe them for their safe behaviour. He may correct the things on the spot if possible, or, may direct the step necessary. He is solely supervising and monitoring for all safety works. This system is useful in small factories but not convenient in big factories. There may be one steward for one plant or different stewards for different departments in one plant. The steward is reportable to his higher officer or to the Safety Department. This old system of safety stewardship is rarely traccable now-a-days.

1.19 Circuit Approach to Safety :

This approach is based on a principle that all safety points should be checked in a sequence (circuit) so that they can be remembered and attended easily. It touches the points coming in line only. The circuit study can be said complete when all the circuits are examined fully, otherwise, it is partial. Depending upon time, each circuit can be checked one by one (the dangerous first) and necessary corrections are made. Thus by this approach partial or full appraisal is possible.

Various industrial circuits are well known. Some circuits and their sequential check-points are mentioned below:

	Circuit	Check-points
1.	Electrical Circuit	Main supply board, OCB / MOCB, transformers, lightening arrester, earthings, cautionary notice, OCB / ACB, fuses, MCC board, starters, relays, motor starter, capacitor, single phase preventer, overload relay, cut-off switches and flameproof fittings in hazardous areas.
2.	Steam Circuit	Boiler, Boiler Mountings such as pressure gauge , safety valve, low water safety valve, coal feeder, damper, oil burner, flow meter, recorder, etc. then on high pressure, low pressure and distribution steam lines up to user points – reducing valve, safety valve, non return valve, steam traps, stop valve, strainer, steam flow indicator and regulator etc. Then on steam using vessel and equipment similar items.

3	Air Circuit	Air filter, compressor, cooler, oil separator, stop valve, air receiver, pressure gauge, safety valve, pressure cut-off switch, air governor, unloader, stop valve, pressure reducing valve, drain valve, by pass valve etc.
4	Water circuit	Stop valve, by pass valve reducers, flanges, couplings, gaskets, and cocks etc.
5	Process Circuit	Depending upon nature of manufacturing process and its flow sequence, various points should be identified listed and approached in sequence. P & I diagram should be used. Chemical process and Gas circuits need more attention.
6	Safe Disposal Circuit	The residues, solid, liquid or gaseous wastes, and constant or accidental emissions of dust, gas, fume, vapour, smoke etc. should be properly scrubbed, neutralized, inactivated and treated in treatment plants to render safe disposal their all control points should be checked in sequence. Actually the process should be designed wasteless by using recycling system.

Only some highlights are given above. More such circuits and more points in each circuit: must be located, inspected and kept safe.

2 PLANT SAFETY INSPECTION

Plant safety inspection is an old and effective method of appraising plant safety. Its techniques are explained below :

2.1 Definitions and Objectives :

As defined by BS 3811-1964 inspection is the process of ensuring by assessment that a facility reaches the necessary standard of quality or performance and that the level is maintained.

As defined by the same standard, maintenance is work undertaken in order to keep or restore every facility i.e. every part of a site, building and contents to an acceptable standard.

Thus maintenance implies some measure of inspection as part of its function to determine (1) what maintenance is needed and when, and (2) whether the results are acceptable.

Safety inspection is defined as 'that monitoring function conducted in an organisation to locate and report existing and potential hazards which have the capacity to cause accidents in the workplace.

Safety and health inspection ensures that working conditions/environment and actions (methods) conform to legal or safety requirement and combine efforts of employers, employees, safety experts and inspectors to create a safe working environment.

Objectives of Inspection are :

1. To find out hazards, accident causes (unsafe conditions and actions) losses and appropriate remedial measures for their prevention and control.

2. To maintain safe work environment, operational profitability and control unsafe actions of people.
3. To check statutory provisions of the Factories Act and similar other safety statutes.
4. To check the effectiveness of the existing systems and to find improvement if required for the purpose of Total Loss Control.
5. To check quality control, product safety. Good Manufacturing Practice (GMP), wear and tear, corrosion, tests and also personnel selection.
6. To gain workers' confidence in organised human activity and factory life.

2.2 Types and Procedures :

Inspections can be classified in many ways as explained below:

1. Planned Inspection : These are of 4 types :

(i) *Periodic Inspection :* Plant, machinery, equipment, lifting machines, pressure vessels, apparatus, procedures, methods and health of the workers should be examined at regular pre-planned period. Statutory forms, checklists, tables and period of inspections, if any, must be strictly followed. Nonstatutory periodicity may be decided according to the need. The whole area should be covered and plant people should be informed in advance for necessary arrangement. It should be deliberate, thorough, detailed and systematic. Safety committee, safety officer, competent person, safety consultant, industrial hygienist, doctors and other safety and health personnel should carry out such inspections.

(ii) *Intermittent Inspection :* It is carried out at irregular intervals to check new equipment installations, procedures and workers; modifications, accident analysis etc. Some partial inspections are also carried out at uncertain intervals.

(iii) *General Inspection :* It is general or routine' inspection to check places which are not covered by .other inspections. Isolated areas, parking places, side - walks, fencing, light - illumination, reporting after long shutdown etc. are checked by such general or overhead inspections.

(iv) *Special Inspection :* Safety or hazard analysis, accident investigation, checking of dangerous operation or vessel, building safety, subjects of complaint only, inspection during special campaigns and new installations, and only for storages, processes, methods, hand-tools, scaffolds, guards, facilities, protective equipment etc., fall within this category.

2. Continuous (ongoing) Inspection: Some personnel like safety officer, maintenance men, electricians etc. spend their all time in observing certain equipment, vessels, processes, operations, safety devices, personal protective equipment etc., to maintain them in safe and efficient working condition. Thus continuous watch and familiarity with employees, equipment, machines and environment are maintained as part of informal and co-operative responsibility.

3. Statutory Inspection : This is carried out by Factory Inspectors and other authorities under various safety statutes (See Chapters 27 & 28) to check the implementation of statutory provisions. Strict and timely compliance is necessary. Breach of law may attract prosecutions. For most of the factories where there is no system of internal inspection, statutory (government) inspection is the only effective inspection and therefore it should be carried out in detail and the governments must employ sufficient staff to achieve better safety inspections. Non-technical workload on Inspectors should be minimised. Inspectors' powers and duties are statutorily prescribed.

Planning and Procedures:

The persons making inspections should be familiar with (1) the know-how and sound knowledge of plant, relevant standards, codes, rules etc. (2) the systematic inspection steps or checklists (3) the method of using data, evaluating and report writing. They should behave like friends, philosophers & guides. They should explain what, why and how. They should know the reasons of past accidents, working unsafely, the safe alternative or remedial measures and they should convince the people for better practice.

Basic Steps of inspection are : (1) To contact the department head for his help (2) To observe all conditions for compliance with established standards (checklists preferable) (3) To observe all operations for unsafe acts or violations of safety rules and (4) To prepare a systematic report with all hazards detected and corresponding remedial measures. The report should include good suggestions of plant people and the recommendations may be discussed with the persons concerned. The report should be sent to the concerned people for compliance and follow-up actions should be continued till full compliance is achieved and reported to the management.

2.3 Non Destructive Testing (NDT) :

See Part 15.5.2 of Chapter 18 for details.

2.4 Safety Checklists :

Process or system checklists are used to identify common hazards and ensure compliance with standard procedures.

A checklist is a convenient means of communicating minimum acceptable levels and hazard evaluation. It can be as detailed as necessary to satisfy the specific situation.

Checklists should be regularly audited and updated. They provide results quickly.

Checklists are complementary to the inspection technique and makes the. inspection more perfect, speedy and systematic. There are so many checklists designed in various ways and differing from plant to plant and person to person based on their knowledge and experience. Industry, plant, process, equipment, tools and machine wise checklists and those for good housekeeping occupy volumes. Therefore some sample points are given below and other checklists (for textile, chemical, housekeeping etc.) are given in respective chapters.

A broad checklist for plant inspection :

1. **Environmental Factors :** Parts most likely to develop unsafe or unhealthy condition because of stress, wear, impact, vibration, heat, corrosion, reaction, misuse or neglect etc.

2. **Machinery :** Pinch points, catch points, shear points, squeeze points, run-in points, operation points etc. Power transmission viz. shafts, belts, gears, pulleys, electric power, unsafe starting or stopping mechanism and machine guarding.

3. **Tools :** Wrong tool for the job, tool in unsafe condition or placed in unsafe position, hazardous or defective hand tools and machine tools.

4. **Work Area :** Flooring-uneven, obstructed, slippery, cramped quarters, exposure to traffic, insecure. piles .or overhead material, poor illumination, glare, temperature -too hot, too cold, exposure to gases, dusts, fumes, vapours etc., hazards from nearby operations; flying or falling objects, electrical, chemical, radiation and trip-fall hazards, work space, aisle, platforms, stairs, railings, spillage, exits, doors, roofs, roadways, yards etc.

5. **Material Handling :** Nature of material or objects heavy, unwieldy, rough, sharp, hot, corrosive, explosive, toxic etc., unsafe handling of equipment-lifts, hoists, chain pulley blocks, containers, conveyors, trucks, cranes, derricks, transport vehicles, elevators, chains, cables, slings and handling methods.

6. **Equipment :** Pressure vessels, revolving and vibrating equipment, pumps and motors, tanks, scrubbers, flares, effluent treatment plants, safety devices, maintenance tools, personal protective equipment, fire fighting equipment, production and related equipment, electrical equipment, power or energy equipment, store equipment etc.

7. **Unsafe Work Practices :** Operating without authority, operation at unsafe speed, guards removed or made ineffective, use of defective tools or using unsafely, handling materials unsafely, standing or working under suspended load ,open hatches, shafts or scaffolds, walking on rail road tracks, driving vehicles wrongly etc., repairing or adjusting equipment in motion, under pressure, electrically charged or containing dangerous substances, distraction of attention, failure to use or using wrong personal protective and fire fighting equipment, poor housekeeping and failure to remedy unsanitary or unhealthy conditions.

8. **Specific Points :** Special check points depending upon specialty of the plant, process, material etc. and points not classified elsewhere should be included here. Special checklists for the points of plant layout, machine guarding, housekeeping, lighting, ventilation, fire, material handling and various processes viz. engineering, textile, chemical etc. are given in the relevant chapters.

   See Part 15.3 of Chapter-18 for checklists of chemical factories.

2.5 Safety Survey:

A safety survey is a detailed examination of a narrower or specific major key area identified by safety inspection or audit, individual plant, procedure or particular problem common to a works as a whole. It is followed by a formal report, action plan and subsequent monitoring. .It is a general inspection of the particular dangerous activities, processes or area.

Its difference with safety audit is evident. Safety audit covers all parts of a plant one by one, while safety survey picks up only one or two most hazardous or important part of the plant and carries out its inspection in depth. It is carried out by an expert team.

2.6 Safety Study :

Here particular area is selected and it is critically studied in details, a report is prepared and submitted to the authority. The study report is useful to all concern. A safety study of one industrial estate examines all or sample factories in the estate for requisite points (mostly in proformas) and gives actual picture of the state of affairs in respect of safety. It spells out number of recommendations and remedial measures based on the study. A report of Hazards in Chemical Factories at G. 1. D. C., Vapi (A Study) by Shri C. G. Pandya and published by Gandhi Labour Institute, Ahmedabad in October 1986 is an example of such safety study.

Similarly within a plant some particular sections, departments, processes or accidents can be selected for safety study. It is desirable that such study should be carried out by experts of that field, otherwise many defects may escape unnoticed. HAZOP, HAZAN, Fault Tree and similar techniques may be utilised for safety study.

Advantages of such safety study are many. It reveals hazards and industrial hygiene effects to be considered at the design stage as well as for operating plants. It gives general picture of an industrial estate studied for safety purpose. It suggests real remedial measures and precautions to avoid accidents. Study of accident analysis suggests appropriate preventive measures.

2.7 Safety Tour :

It is an unscheduled examination of a work area carried out by works managers or safety committee members to ensure that the standards of housekeeping are at an acceptable level, hazards are removed and safety standards are observed. Its scope is less than that of a safety inspection. It is general inspection of the workplace.

2.8 Safety Review :

Its purpose is to identify unsafe conditions or operating procedures that could lead to an accident. It ensures that the plant and procedures (operating and maintenance) match the design intent and standards. The procedure

- initiates application of new technology to existing hazards.
- Reviews operating procedures for necessary revisions.
- Reviews adequacy of maintenance of safety inspections.
- Keeps plant personnel alert to the process hazards.

2.9 Safety Sampling :

It is a systematic sampling of particular dangerous activities, processes or areas. Its a method of measuring hazard or accident potential by random sampling and by counting safety defects while touring specified location by a prescribed tour of @ 15 minutes at the weekly intervals. The quantum of defects noticed is used to portray trends m safety situation. The point on a safety sampling sheet includes items such as nonuse of personal protection, obstructed fire exits, environmental factors, lighting, ventilation, temperature, faulty hand tools, guarding position etc. The results are collected by the Safety Officer and presented in graph form to monitor the effectiveness of the safety programme.

Formula $N = \dfrac{4\,(1-P)}{V^2\,(P)}$

gives number of observations N,

when percentage of unsafe operations P and Value of accuracy V (normal value = 10%) are known. For example, if during preliminary survey of 60 observations, 20 were found unsafe, then

$$P = \frac{20}{60} = 0.33\% \text{ and } N = \frac{4\,(1-0.33)}{(0.10)^2(0.33)} = 812.12$$

This means 812 sample observations would be required to ascertain various unsafe practices with an accuracy of 10%. If 200 observations are possible in one tour, four tours (three tours of 200 and last tour of 212 observations) will be required for satisfactory results.

This technique was first employed by American chemical plants and then by ICC's Dyestuffs Division in UK. It is based on Heinrich's ratio 1:29:300 opportunities must be observed before one lost time accident. It is based on samples and not on detailed surveys.

It's difference with safety tour is that the tour is an unscheduled examination of work area by a team of safety personnel and may last for a longer period to assess safety standards, while safety sampling is a short tour of @ 15 minutes, generally by one observer for the purpose of random sampling of visible defects and to mark them on a sampling checklist.

Steps of the technique are :

1. List safety defects and hazards applicable to the area.
2. Define routes-at least two per section or department-which the observer can traverse within 15 minutes.
3. Train the observers for correct use of their respective routes and printed checklists.
4. Tell the workers the purpose of safety sampling.
5. Observers must meet at a convenient place once a. week or fortnight. One observer should cover one route alone and mark his sheet.
6. Defects found should be corrected by supervisor or Department Head.
7. Results of Sampling Check List are added to summary sheets and plotted on a graph.
8. Comparing with the graphs of past period, deviation in the safety performance is noted and safety measures are decided to improve the performance.

Advantages or Benefits of this technique are :

1. Management is provided with a week by week picture of accident potential.
2. Defects are cleared at least once a week. Many defects are cleared on the spot.
3. Supervisors' eyes are sharpened by practice and begin to be more vigilant.
4. Supervisors and Managers are put on the spot when they fail to take action after the defects have been pointed out to them.

Subjects of Safety Sampling Checklist are:

1. Protective Equipment-Non use or misuse of guards, fire extinguisher, first aid box, safety notice, machine under repair etc.
2. Protective Clothing - Non use, misuse or defects of goggles, mask, gloves, helmets, safety boots etc.
3. Housekeeping-Blocked passage way, stairways, slippery patches, chemical spillage, blocked drains, tripping hazards etc.
4. Tools-Wrong or defective tools, using or towing tools unsafely, power tools, plugs, wiring etc.
5. Unsafe Conditions-Leaking joints, valves etc., fans not working, -poor supports, unsafe scaffolding, erection, lifting machines, pressure vessels, dress, design and construction, improper illumination, ventilation, material position etc.
6. Unsafe Actions - Adjusting, cleaning or oiling machinery in motion, operating at unsafe speed, making safety device inoperative, distracting/ teasing, taking unsafe position, wrong ladder

position, unsafe method, carrying heavy load, hand trucks unsafely loaded, persons riding on fork lift, trolleys, machine part etc.

2.10 Contact Scheme :

Here supervisors are directed to contact the workers under their control, to talk with them at the work place regarding safety points viz. wearing eye protection, providing guard, clearing work benches, tool condition etc. and to put a tick mark on the Contact Scheme Card designed for this purpose. This method is useful for on the spot correction and motivating people for safe attitudes.

2.11 Good Manufacturing Practice (GMP):

This concept was first developed by the Pharmaceutical Manufacturer Association, USA in 1961 and first GMP regulations were issued by U. S. Food and Drug Administration in 1963 and was subsequently adopted in 1969 by the World Health Organisation (WHO). Thus this concept originated for quality control in pharmaceutical industry is also useful for other industries, because, it helps in overall improvement in manufacturing practices by four quality elements of men, machinery, materials and methods. Points included in GMP are:

1. Hygiene.
2. Product security.
3. Importance of labelling.
4. Defined procedures, SOP, SOI, PO etc.
5. Cross contamination.
6. Housekeeping and
7. Safety.

GMP brings us nearer to the ultimate good products with built-in quality and safety.

WHO requirements for GMP are personnel, premises, equipment, sanitation, starting materials, manufacturing operations, labelling and packaging, quality control system, self inspection, distribution records and complaints and reports of adverse reactions.

All processes, procedures, records and systems are clearly defined, personnel and operators are trained and records are well documented for quality and safety assurance at every stage.

2.12 Recommendations & Follow Up Actions (Compliance) :

The inspection report should be clear and concise with enough explanation, to make it understandable. Copies of the recommendations should be sent to the concerned persons for implementation. Progress should be reported to the management at regular intervals. Periodic checks should be made until they have been fully complied. In case of government inspection, the compliance report should be sent to the authority within the time limit.

Rule 19 of the MSIHC Rules, 1989 and Rule 68J(13) of the GFR speaks of improvement Notice" that may be served by the authority for compliance of contravened provisions or matters leading to that contravention. The occupier shall remedy that and any other measures (directions) specified within 45 days or the period also be specified.

2.13 Responsibility for Inspections :

Safety inspection cannot be carried out effectively by any one agency or individual. The responsibility should be shared by all concerned. All personnel at the various levels should clearly understand their responsibilities and functions so that management's objectives are implemented through their co-ordinated efforts.

Safety Officer, Safety Committee and Line Management comprising of senior plant managers, first line supervisors, engineers and workers are all responsible for effective inspections and their speedy compliance.

3 ACCIDENT INVESTIGATION, ANALYSIS AND REPORTING

3.1 Philosophy :

Philosophy of industrial accident investigation should be clear and well explained to workers. It should not be oriented toward fault-finding and blaming any individual. It's main objective is to find out the real cause (s) of the accident and then based on it, to suggest appropriate remedial measures to prevent its recurrence.

For gross unsafe action, negligence, omission or personal fault, attention of the person should be drawn explaining him the consequence and to improve himself not to commit such act in future. He should be properly trained if necessary. See Part 3.5 for accident analysis.

3.2 Purposes of Investigation and Report:

The main purposes arc :

1. To learn accident causes so that similar accidents can be prevented by improvement of working conditions, actions and supervision. This helps in designing accident prevention strategies.

2. To make the hazard known to the management, workers and supervisors to direct their attention to accident prevention.

3. To find facts to determine legal liability and information for preventive purposes. If the purpose is 'to fix blame or responsibility', vital information will often be withheld or distorted. Therefore an investigation should be for the preventive purposes to disclose facts and not faults.

4. To establish procedure to combat damage claims under compensation laws.

5. To determine the 'change' or deviation that produced an 'error' that in turn resulted in an accident (systems safety analysis).

6. In case of accident affecting the society as a whole the Government may intervene for the purpose of banning of the hazardous material or process.

7. To find out injury rates to compare safety performance.

8. To use the record for the purpose of job safety analysis.

9. To develop safety rules, procedures, bulletins, posters and material for safety meetings and motivation and

10. To amend die safety law if it is thought necessary by the Government.

3.3 Process and Types of Investigation:

Process of investigation includes observation at site, interrogation with workers, fact findings, judgement and recommendations.

Some objective questions to be considered and answered by the investigator are : Who was injured, what was he doing at that time, where was he, who was with him, what he has to say about happening, what part of the injured is involved, how was he injured, what was unsafe-the condition, the method or the action of the injured? what does the medical report suggest, what safeguards should be used, what safeguards are provided to prevent recurrence and what are yet to be provided. Such and similar other questions and their answers constitute a Supervisor's Accident Report.

The first requirement for the injured person is to provide him medical treatment. It is a mistake to make him upset by questions. It is advisable to wait till he recollects his thoughts and gets his nerves under control. Initial story should be collected from spot checking and interrogation with co-workers and eye-witnesses. There should not be delay in initial inquiry. The conditions should be kept unaltered pending the investigation. Photographs, sketches, notes, computer and DCS records etc. will help much. Chronological questions should be asked and the concerned facts should be collected viz. testing reports, registers, documents, instructions, defective or damaged parts etc. The fact findings should aim to determine exact causes of the accident. All causes should be considered and classified according to severity and responsibility for preventive purpose. As the last step, suggestions and recommendations for the prevention should be submitted in writing. An emphasis should be put to suggest engineering controls than to suggest human responsibilities. If it needs, training methods should be suggested. Effectiveness and practicability of the recommendations should not be forgotten. Implementing difficulties should be considered and replied. Then the report is sent to the management for implementation.

All fatal and serious accidents and dangerous occurrences must be investigated thoroughly and all reportable, non-fatal and repetitive accidents should also be inquired. If time permits non-reportable and near-miss accidents should also be investigated.

Types of Accidents are mentioned in Part 8.1 of Chapter-4. Accident statistical forms are given in Part 9 and 12 of Chapter-5. Accident classification (analysis) is explained in Part 3.5 following. Types of investigations depend on the circumstances and objective of each case. Some types are failure mode and effect analysis, HAZOP, fault tree, event tree, cost effectiveness, statistical method, critical incident method, system safety etc. as described in foregoing two parts of this Chapter.

3.4 Agencies investing accidents :

In case of statutory reportable accidents, generally factory inspectors (Govt. Labour Dept.) investigate, but, because of -a $mall number of staff and big number of accidents in hundreds of factories in their charge, obviously, they cannot investigate all small accidents reported to them. They investigate serious and fatal accidents and give detailed report showing the facts, breach of law if any, and remedial measures. They may order to prohibit the use of some plant, equipment, process or premises if it is found of imminent danger to them. Investigation of Bhopal accident resulted into an order of permanent closer of the factory. A committee may be constituted by the Govt. to inquire into serious accidents. The finding may be used to amend the safety law if required.

Major, permanent and immediate responsibility of accident investigation lies upon the factory management and it is in their interest also. Even then it is noticed that majority of the small factories have not yet thought to self-inspect or investigate their own accidents. They simply report and rest upon the insurance. This is not good. Each factory should have its own system or arrangement to investigate accidents, hazards and to suggest and implement the remedial measures. This is most advisable and useful for the purpose of safety. They may utilise safety consultancy services of safety specialists.

Depending upon the gravity and nature of the accident, it may be investigated by foreman or supervisor, safety officer or engineer, safety committee or an expert group including consultants. The supervisor should report and investigate each accident, as he is the nearest man having more knowledge of the accident facts and remedial measures. The safety officer should investigate each important accident for his own information and report to the top management for necessary steps. His specialised knowledge, training, experience and ability make his report more valuable and useful in preventing recurrence. The safety committee's report is sometimes more effective as it carries workers' voice as representatives in the committee and rich knowledge of the Department Head.

The information gained from accident investigations should be used throughout the establishment where it is applicable. All similar or identical possibilities should be judged to prevent similar accidents.

3.5 Accident Analysis (Classification)

Investigation and analysis go together. The facts found form the investigation are first analysed. The analysis should reveal one hypothesis to explain all the facts adequately. Result oriented Objective Analysis procedure should include the following :

1. Identify and locate the main source of accidents from actual experience, materials, machines, tools, jobs, men and methods most likely to produce injuries.

2. Disclose the nature and size of the accident problem in departments and among occupations.

3. Indicate the need for engineering revision by identifying the unsafe conditions, materials, equipment and environment.

4. Disclose inefficient operating procedures, processes, poor layout and outdated methods to reduce accidents.

5. Disclose the unsafe practices for training of employees.

6. Disclose improper placement of personnel in instances of handicaps contributing to accidents.

7. Guide supervisors to use their maximum time for safety work by providing them information about the hazards in their departments.

8. Evaluate the success of a safety programme by continuing analysis of the effects of different safety measures, educational techniques and other methods to prevent injuries.

3.5.1 As per IS : 3786

The principal factors related to causation of accidents are : (a) agency (b) unsafe mechanical or physical condition (c) unsafe act (d) unsafe personal factor (e) type of accident (f) nature of injury and (g) location of injury.

A standard classification as given in Appendix B of IS:3786 could serve as a guide for detailed analysis of accidents for the study of various causative factors and their relationships.

The major divisions are given below. For details the Appendix -B should be referred.

B-l Classification According to Agency.
B-2 Classification According to Unsafe Material or Physical Conditions.
B-3 Classification According to the Unsafe Act.
B-4 Classification According to Unsafe Personal Factor.
B-5 Classification According to Type of Accident.
B-6 Classification According to Nature of the injury.
B-7 Classification According to the location of the injury.

Example 1 :

A lathe operator lost his two fingers of left hand when it was trapped in the nip of unguarded speed changing pulley belts when the start switch lever was accidentally turned to 'on position' by striking his body to the lever. Analyse this accident by identifying the key facts (factors) and causes of this accident.

S. No.	Analysis	Key Factors (Causes)	Part of IS : 3786
1	Agency --	Speed changing pulley belt of the lathe	2023
2	Unsafe condition --	(1) Unguarded pulley-belt (2) Start switch of the wrong type	10
3	Unsafe Act	Taking unsafe position of posture	60
4	Unsafe personal factor	Nil	
5	Type of accident	Caught between moving objects	133
6	Nature of Inquiry	Amputation of two fingers	340
7	Location of injury	Fingers	447

Example 2:

A helper in a chemical plant while transferring 2-4 dichlorophenol in a carboy through pumping and with tight fitting rubber hose-pipe inserted in the carboy without venting was splashed by the chemical came out due to rupture of the pipe, died within 15 minutes. He has not worn the PVC overall and hand gloves. Analyse this accident as per IS Classification.

S. No.	Analysis	Key Factors (Causes)	Part of IS : 3786
1	Agency --	Toxic Chemical	2324
2	Unsafe condition --	1. Rubber hose - pipe 2. No venting while filling i.e. hazardous arrangement.	30

3	Unsafe Act	1. Not wearing protective equipment and Not allowing air vent in the carboy i.e. unsafe placing.	50
4	Unsafe personal factor	Nil	
5	Type of accident	Contact by absorption of harmful substance.	171
6	Nature of Inquiry	Death by acute poisoning	370
7	Location of injury	Upper limb, multiple locations	448

Thus seven key factors (facts with causes) are explained above by two examples. These factors are defined and classified in Appendix B of IS:3786. Also refer Chapter-30 for case studies of number of such accident cases and try to classify them accordingly.

Relative importance of proximate cause and accident (key) factors in any accident investigation is evident from above examples and case studies. The proximate cause (unsafe condition/action) explains the phenomena of accident and suggests the appropriate remedy to prevents recurrence. If the cause is not known, selection of remedy and its application are not possible. Other accident factors viz. agency, type, nature and location of injury explain the classified effects of an accident which are useful in determining type of guard or guard position, safety device, protection from dangerous contact and type of personal protective equipment necessary.

3.5.2 As per the Directorate of Industrial Safety and Health and Labour Bureau

Statutory accident reports received by all Factory Inspectorates are classified as below. Labour Bureau, Shimla also publishes the accident statistics in the same classification. Only the major heads are given and for further details the full classification list should be referred.

Personal Faults

Material and Mechanical Faults

(i)	Lack of training	(i)	Physical hazards
(ii)	Chemical hazards	(ii)	Chemical hazards
(iii)	Poor discipline	(iii)	Poor housekeeping
(v)	Others	(iv)	Improper clothing
		(v)	Others

Textile Machinery:

1. Opening & Blow room m/c.
2. Cardroom m/c.
3. Drawing Frames
4. Speed, Stubbing, Inter and Roving Frames.
5. Spinning m/c.
6. Weaving m/c.
7. Finishing ni/c.
8. Flying shuttles. 8A Nip Accidents.
9. Other Miscellaneous textile m/cs.

Non-Textile Machinery and others:

101 Prime Movers
102 Shafting
103 Transmission m/c.
104 Lifting m/c.
105 Power Presses
106 Others
107 Circular Saws
108 Planning m/c.
109 Vertical Spindle moulding m/c.
110 Others
111 Rollers for calendar mixers etc.
112 Others
113 Power shunted Railways
114 Manually shunted Railways
115 Power driven vehicles
116 Manually handled vehicles
117 Electricity
118 Explosions
119 Fires
120 Gassing
121 Molten metal & Hot substances
122 M/c not moved by mechanical power
123 Others
124 Handtools
125 Struck by falling body
126 Falling from heights
127 Falling on the flats
128 Falling into pits etc.
129 Stepping on or striking against objects
130 Handling goods or articles
131 Others

Accident classification is required industry class wise. Therefore Industrial Classification should be seen together.

3.6 Industrial Classification. (NIC-1987):

Accident causation classification and classification should be studied together for data of industry wise and causation wise See Table 5.22 of Chapter-5.

National Industrial Classification (NIC) India, 1987 is a four digits classification of all industries in India and is extensively used to classify factories according to their manufacturing process or activity and to arrange them for national labour statistics.

3.7 Accident Investigation Report and its Content:

3.7.1 Types of Reports :

After analysis the next step required is to write a clear and purposeful report in the report form. Statutory forms viz. Form No. 21, 22 and 29 under the Gujarat Factories Rules should be filled in first and sent to the authorities within stipulated time. As these forms do not provide sufficient information for the purpose of accident causation, analysis, costing and preventive measures, new forms should be designed and utilised for internal use. Part 9 of Chapter-5 provides such detailed Accident Statistics Form and Accident Cost Form for above purposes. Part 12 of the same Chapter provides useful tables for keeping a purposeful record of safety statistics. Such report forms and records must be written clearly emphasising the detailed causation and consequences of accidents and their usefulness in searching remedial measures.

Some Accident Report and Analysis formats for internal use are given below.

Format 1: Incident / Accident Investigation Report

(To be submitted immediately after the incident)

Name & Address of the Factory: Sr. No. ____________
Date ______________

1. Contractor ____ Project : ______________________
____

2. Date of Incident ____________________________________ Time _________ Location _______

3. Event (a) Personal Accident _____________ ☐ (d) Pollution Contamination ☐
(b) Fire or explosion ______________ ☐ (e) Spillage / Gas Release ☐
(c) Mechanical Failure _____________ ☐ (f) Others ☐

4. Result (a) Injury _____________ ☐ (d) More loss of Mandays ☐
(b) Material Loss _____________ ☐ (e) Property Damage ☐
(c) Near-miss incident _____________ ☐ (f) Environmental Pollution / Others ☐

5. Name of the Injured : ____
Age ___________ Sex ________ I.D No. _____________________ Trade __________________
6. Hours at which he started work on the day of injury _______________________________
7. Description of Incident (Describe what the involved person was doing, Mention the exact location / area of incident and equipment)
____
____
____
____
8 Specify the injury (i.e. state the extent of wound/ fractures etc.)/ damage (Approx. Loss)
____
9 (1) If caused by Equipment / Machine give name _______________________________________
(2) State whether it was moved by mechanical power at that time ______________ Yes / No.
10. Where there any unsafe conditions ? ____
11. Whether any unsafe act was done by him ? ____
12. Protective clothing / equipment used ? What ? _____________________________________
13. Was he under influence of Liquor / Narcotics ? Yes/No.
14. (1) Whether job safety analysis was explained to him ? ______________________________
(2) Who explained it ____
15. How long will he remain away from work : ____
16. State whether the medical aid given to him ? ______________________________________
17. Probable causes of Incident ? ____
____
18. Describe what steps should be taken to prevent such recurrence in future __________________
____
19. Name of Witness : (1) Name ____________________________ Dept. ____________________
(2) Name ____________________________ Dept. ____________________
20. Name of Resident Engineer / Engineer-in-charge ____
Date _________________________ Signature _______________________________________

Format 2: Incident / Accident Investigation Report

(To be submitted immediately after the incident)

Name & Address of the Factory:

Sr. No. ____________
Date ______________

First Aid	Recordable Non Lost Time	Lost Time reportable

Fire	Spill & Leak	Near Miss Property Damage

1. Name of the injured person :
2. Contractor :
3. Plant/Section :
4. Employee Code No./Designation :
5. Age/Sex :
6. Date & Time of Incident :
7. Normal Working Hours :
8. Location of Indicent :

Area	Equipment No.	Name of Equipment

9. Type of Incident :
10. Nature of Incident :
11. Body part injured :
12. Extent of Material LOSS/Property Damage :
13. Details of Incident
    a. Sequential Occurrence Description :
    b. Activity of the injured at the time of Incident :
    c. Observations & Inference :
14. Conclusion:
    Probable Causes:
    a. Immediate causes:
    b. Basic/Root causes:
15. Preventive Measures :

Sr. No.	Recommendations	Action By	Date	Status
1.				
2.				

16. Evaluation :

Severity Potential			Probability Potential		
Major	Serious	Minor	Frequent	Occasional	Rare

17. Investigated By :

Fire & Safety Dept :
Plant concerned :

18. Discussed & Reviewed OR to be discussed & reviewed at
19. Copies for Action to :

Signature

Name & Designation

Format 3: Work Injury Investigation Report
(To be submitted immediately after the incident)

Name & Address of the Factory:

Sr. No. ____________
Date ______________

If not employed by Company, Contractor's Name & Address ______________________________

<table>
<tr><td colspan="12">Nature of Injury</td><td colspan="11">Parts of Body Affected</td><td>Struck against</td></tr>
<tr><td rowspan="8">Abrasion</td><td rowspan="8">Contusion</td><td rowspan="8">Laceration</td><td rowspan="8">Cut</td><td rowspan="8">Puncture</td><td rowspan="8">Sprain</td><td rowspan="8">Fracture</td><td rowspan="8">Foreign Body</td><td rowspan="8">Burns (chem..)</td><td rowspan="8">Chemical Exposure</td><td rowspan="8">REsp. system</td><td rowspan="8">Head & scalp</td><td rowspan="8">Face & Neck</td><td rowspan="8">Eye</td><td rowspan="8">Arms & Fore Arms</td><td rowspan="8">Hands & Fingers</td><td rowspan="8">Chest</td><td rowspan="8">Abdomen</td><td rowspan="8">Back</td><td rowspan="8">Thigh/Leg</td><td rowspan="8">Knee</td><td rowspan="8">Foot</td><td rowspan="8">Any other (Specify)</td><td>Struck by</td></tr>
<tr><td>Caught in</td></tr>
<tr><td>Fall from height</td></tr>
<tr><td>Slipped on ground</td></tr>
</table>

Category	Minor	Name : __________ E.C. No. ____________ Age : _______ Sex :___	
	Recordable Non lost time	Designation : ___________ Dept/Plant:_________ Section:__________	Contact with Chem.
		Date of Accident : __________ Time : _________ Place : ____________	
	Recorable Lost Time	Injured came on duty : Date : ______________ Time : ______________	Contact with Temp.

Description of Accident :	Arrived at Medical Centre at : __________ Hrs. Departure From Medical Centre at : _______ Hrs. Treatment Given :	Inhalation Ingestion
Exactly what the injured was doing :	Treatment at Medical Centre ( ) Yes ( ) No Referred to Hospital ( ) Yes ( ) No Fit for Duty ( ) Yes ( ) No	Machine Vehicles
If exposed to Chem.:____() Sligth ()Severe	If unfit, __________ Days w.e.f _____________	Tools
Name of the chemicals: ________________	Likely Loss Time ______________ Days/Hours Remarks (if any) :	Conveyors
State of Chemicals : () Gas () Liquid () Solid ( ) Hold () Cold ( ) Room Temp		Stairs/Ladder
Whether Safety Equipment was being used Yes No Safety Glasses ____ ____	Signature of the Medical Officer / Shift	Electric App. Chemical

Safety Shoes ____ ____		
Helmet ____ ____	Nurse ________________________	
Hand Gloves ____ ____	Name : ________________________________	
Face Shield ____ ____		
Gas Mask		Others (Specify)
PVC Clothing		
SBA		
Safety belt		
________		

Format 4 : Statutory Accident Forms:

(1) Under Gujarat Factories Rules 1963 - Form No. 21, 21-A, 22 and Sch. 6 u/r 68-J.
(2) Under MSIHC Rules 1989 - Sch. 6.

These statutory accident forms should be referred from the law books and should be sent within prescribed time limit.

Statutory Report:

A good management should keep a system of investigating and recording all injury cases-major, minor and all first aid treated cases-as well as cases of damage to property or environment. Accident Register (Form no. 29 GFR) and Health Register (Form No. 20 GFR) must be kept up-to-date. Accident Reports (Form No. 21 GFR) must be filled in details, attached with the detailed investigation reports, properly classified and filed.

Annual reports should also be prepared to compare the year to year performance. The reports should be reduced to simple charts, graphs or computer data. Safety bulletin may be prepared and circulated to read such data. Publication of typical accidents, their causes & remedial measures etc., accident rates, safely award winners etc. will promote safely and motivate people. Safety reports circulated among industries make them alert. Reports sent to the Government are useful to many industries, as the Government feeds such information to planners to help them to decide upon the course of action. It may be of State or National interest to discuss safety reports (from the Chief Inspector of Factories and others) in the Legislative Assemblies or the Parliament. Publicity of the abstract of safety reports through TV, radio, books and newspapers are also desirable.

3.7.2 Content of Accident Investigation Report:

An Accident Investigation Report (Remarks) should contain

1. Name and address of the factory.
2. Name and address of the investigator (inspector) and with whom.

3. Facts finding-including date, time, place and manner of the accident, persons involved, result, facts seen or known by the investigator, facts stated by the workers injured and the co-workers who saw the accident, facts stated by other persons and facts of judicial notice.
4. Drawings, photographs, sketches, records, registers, documents and computer printouts pertaining to the accident.
5. The process at the time of the accident.
6. The causes of the accident in details and with break-up.
7. The remedial measures.
8. The breach of law if any.
9. Compensation to be paid and information for insurance purpose.
10. The delivery of the report to whom and how.

The statements recorded should be enclosed. Such reports should be preserved till the legal cases are over and to use them for preventive purpose.

Primary responsibility to report accident lies upon the supervisor. First he will report to the management. The routine of reporting may vary according to the size and set-up of the plant and its organisation. The safety officer/engineer should go through the supervisor's report and should put his comment or notes. He may further inquire for his satisfaction or more details. The top management will report to the Government and should take keen interest in going through the report and to implement it. The safety officer's report should include trend of injury rates, total time lost, cost of the accident and his suggestion to improve safety and to save unwanted cost.

3.8 Methods of Collating and Tabulating Data :

For analysing a small number of reports the tabulation by hand sorting and tallying is efficient. Its advantage is that the original records are being used and all the information is available for reference.

For analysing and filing a large number of reports, keysort cards may be used. This card contains the information of the original report. The code numbers assigned to the various factors may be punched in the cards so that they can be sorted by a special needle. Sorting is a hand operation.

A third method of tabulation uses card tabulating machine. Here the code numbers only are punched into the cards which can be quickly and accurately arranged into various groups. This methods is very useful when the number of reports is very large, when many classification and cross or sub classifications are required or when tabulation of numerical data such as days lost etc. are necessary.

Modern method of computer processing can also be utilised for such tabulation. See part 13 of Chapter5 for management information system (MIS).

3.9 Follow-up for Corrective Action :

Merely obtaining, recording and tabulating of safety data is of no use. It must be followed by necessary corrective action to provide safe working condition, to teach safe working actions, to improve existing training system,, to make new safety rules necessary to improve inspection techniques and analysis to design -posters, safety manual and positive actions to minimise accidents.

Follow up action must be and should consider every compliance. Reasons of prompt and immediate recommendation for not following the recommendation or delays necessary to make changes should be explained. The accident causation should be applied to all identical cases in other departments also to prevent similar recurrences.

3.10 Record Keeping :

Record of accidents reported to the plant management and to the Government authorities, facts collected as a result of investigation, analysis of the facts, conclusion about remedial measures necessary and status of implementation of those measures must be kept in a well documented form. Computer is more useful in this regard. In DCS system, printouts of accident situations at the time of accident should be kept out and preserved.

Safety department should design formats of safety records applicable to the factory, train personnel to fill such records and maintain them.

Records keeping may be ordinary or computerised and in much details. Good record is always useful for

1. Studying past accident causes and remedial measures concluded.
2. Monitoring status of implementation of safety measures.
3. Taking decisions regarding future action in the matters of safety.

Period of maintaining record should be decided depending on the utility of the subject matter.

4. HAZARD AND RISK ASSESSMENT TECHNIQUES:

This subject requires clear understanding of definitions and difference between hazard and risk, analysis and assessment etc.

4.1 Hazard, Risk & Detection Techniques:

For definitions of hazards and risks see parts 3.34 and 3.75 of Chapter 2.

Risk results from hazard i.e. an unsafe condition, action or .situation. Risk is the probability of frequency of hazards during a certain period (e.g. 2 explosions per year, 20 fires per year, 5 accidents per month, 200 fatalities per year, I disaster per 10 years etc.). Therefore if hazard is identified and 'removed first, risk is automatically reduced.
Some definitions are as under:

Hazard is the inherent property of a substance or unsafe condition, unsafe action or situation to cause harm which may cause human injury, damage to property or the environment or some combination of these criteria.

Chemical Hazard is a hazard due to chemical (including its storage, process, handling etc.) and it is realised by fire, explosion, toxicity, radiation etc.

Risk is the likelihood, chance, frequency or probability of an undesired event (i.e. accident, injury or death) occurring within a specified period or under specified circumstances and its severity, effect or consequences.

As per example risk of death for a man aged 30 is $1x10^{-3}$ per annum and that for a man aged 60 is 1×10^{-2} per annum.

This means death possibility of a man aged 30 is I out of 1000 per year, while that of a m<in aged 60 is I out of 100 per year. Risk unit '1×10^{-n} means 1/10" i.e. one time event out of- 10^{n} such occurrences during a period (e.g. I year).

Individual Risk is the frequency at which an individual may be expected to sustain a given level of harm from the realisation of specific hazards.

Societal Risk is a measure of the chances of a number of people being affected by a single event or set of events and is often presented as f/n curves, (i.e. frequency v/s number of people affected).

Almost all human activities involve some risk and zero risk is not possible. Therefore the concept of Acceptable risk is developed and Fischoff defines it as 'the level which is good enough where the advantages of increased safety are not worth the extra costs of reducing risk'. Thus it indicates the balancing condition of accident costs v/s preventive costs. Hazard and Risk distinguished:

For example, banana skin lying on the road is a hazard but 2 persons falling per hour due to that, is a risk. Non-provision of safe overflow pipe is a hazard but weekly overflowing of the tank due to that, is a risk. Process of sand blasting is a hazard but contracting of silicosis by a worker at any point of time, is a risk. Storage of toxic gas is a hazard but due to its escape and effects, probability of deaths of 100 persons per 10 years, is a risk. Not providing a 'safety valve is a hazard but bursting of vessel once In 5 years, is a risk. Bad housekeeping is hazard but 2 accidents per month or 20 workers leaving the job every year due to it, is a risk.

Thus identification, analysis and assessment of hazards are different than the identification, analysis and assessment of risks, though both are interrelated. Factors of tune, frequency or ill effects (consequence) are added in 'risk' distinguishing it from 'hazard'.

Some definitions relevant to risks are as under :

1. **Exposure to Risk :** A situation created whenever an act or omission gives rise to possible gain or loss that cannot be predicted.

2. **Cost of Risk :** The cost imposed upon organisation because of the presence of risk. Its component parts are (1) the cost of losses that do occur and (2) the cost of uncertainty itself.

3. **Risk Management :** A general management function that seeks to identify, assess, address, control and review the causes and effects of uncertainty and risk on an organisation. It includes assessment, control, financing and administration of risk as defined herein below.

4. **Risk Analysis :** Technical process of identifying, understanding and evaluating risk (analysing cause and effect wise).

5. **Risk Assessment :** It is a judgement of significance or activities that enable the risk manager to identify, evaluate and measure risk and uncertainty and their potential impact on the organisation.

   This judgement can be taken when the measured value of hazard or risk is compared with the value or standard legally or otherwise prescribed. This calls for an expertise of an industrial hygienist.

6. **Risk and Uncertainty Assessment :** All activities associated with identifying, analysing, measuring, comparing and concluding risk and uncertainty.

7. **Risk Control :** All activities associated with avoiding, preventing, reducing or otherwise controlling risks and uncertainties.

8. **Risk Financing :** Activities providing means of reimbursing losses (i.e. finance for the cost of risks and losses) that occur and that fund other programmes to reduce risks and uncertainties.

9. **Risk Administration :** Activities and strategies associated with the long-term and day-to-day operation of the risk management function.

10. **Risk Selection :** The control technique best described as the conscious acceptance of risk in accordance with an organisation's overall goals, objectives and risk taking philosophy.

11. **Risk Avoidance :** A risk control technique whereby a risk is proactively avoided or abandoned after rational consideration.

12. **Loss Prevention :** Those strategies and activities intended to reduce or eliminate the chance of loss.

13. **Loss Reduction :** Activities minimising the impact of losses that do occur.

14. **The Risk Chain :** Five elements or links connected with accident i.e. hazard, environment, interaction, outcome and consequence.

15. **Subrogation :** Risk transfer by legal document as a loss reduction tool.

16. **Risk Transfer :** If risks cannot be controlled, the last resort is to transfer the risk by contract of job, or property or insurance to pay for losses.

17. **Risk Retention :** A risk financing method in which the organisation experiencing a loss retains the risk by self financing or borrowed funds, or by a group to which the organisation belongs. Retention may be passive or active, unconscious or conscious, unplanned or planned.

18. **Information Management** (as a risk reduction tool) : The use of information for the express purpose of reducing uncertainty or for enhancing stakeholder awareness or knowledge of organisational risks.

Hazard detection techniques :

Unsafe acts and unsafe conditions must be observed to find out hazards. Statutory accidents reports (e.g. Form 21 & 29 GFR) should be seen to detect past accident causes. Unsafe acts due to psychological and physiological personal factors should be detected as explained in Chapters 3 and 4. Hazards of unsafe conditions are mechanical, electrical, chemical (including radiation) and environmental. Some hazards are visible and some invisible.

Visible hazards can be detected by various techniques such as (1) Plant inspection based on statutory requirement, checklist, safety survey, safety audit and safety sampling (2) Detection and monitoring systems (3) Functional test of machinery and equipment (4) Accident investigation (5) Repair shop (6) Store consumption and (7) Shop feed back etc.

Examples of visible hazards are unguarded machinery, bad housekeeping, wrong practices etc. To discover such hazards careful planning and inspecting system is necessary. Some steps are : (1) Make a list of all statutory applicable provisions of the Factories Act and other Acts, make a survey of the plant to compare the existing provisions and find out the missing provisions (hazards) for implementation (2) Make a list of materials, processes, operations, vessels, equipment, machinery and classify them as hazardous and non-hazardous. Chemicals should be classified according to their hazardous properties. (3) Prepare layout of plant, machinery, equipment, premises and utility services like power, water, air, gas and heating / cooling media. From these prepare a list of possible hazards. (4) By means different techniques mentioned in Part I and 2. Further details of the hazards should be detected and (5) By means of a detailed inspection report preventive measures should be suggested.

Invisible hazards like gas leaks, concentration of toxic and hazardous vapour, malfunction or failure of machinery, equipment, pressure plants and miscellaneous environmental factors may cause sudden accident and heavy damage. They must be detected and controlled by built in self corrective systems. The devices used are detectors, recorders, alarms, trips, probes, sensors, limit switches, meters, analysers, electronic or auto controls, scrubbers, incinerators etc.

In modern machines various automatic movements take place near and around point of operation. Feeding devices, clamping action and work head movements should be interlocked with each other. Each position of these elements must be sensed and linked with command controls. Any malfunction of moving elements is indicated on audio-visual panel and the machine stops.

Repair shop data reveals clues to unsafe conditions like poor design, defective material, poor construction, wear and tear etc. Repetitive repairs indicate major hazards. Similarly store consumption data also indicates some defects. There should be a regular feedback of information from repair shop, stores, operators and foremen to monitor hazards and to take corrective actions.

Heating equipment should have temperature controllers and additional thermostats for better protection and to give audio-visual signals and to cut off power supply or heat source. In furnaces using flammable fuel in scaled chamber, the components are charged through hydraulically operated carriages and such carriages, fuel flow and flame curtain are sensed by various gadgets like photo-sells, probes, limit switches etc. Failures are sensed and indicated o panel. Suitable corrective actions are automatically taken viz. purging nitrogen etc. Toxic exposures are neutralised by scrubbers. Flammable exposures are controlled by flameproof fittings, flare and vents. Effluents are treated in 'treatment plants to nullify their harmful effects.

4.2 Hazard and Risk Progression Chart:

Process of Risk Management in six stages is explained below in a progression chart

Hazard and Risk Study Progression Chart

Stages of hazard and risk studies	**Hazard identification**	**Hazard analysis**	**Risk analysis**	**Risk assessment**	**Risk management**
1. Identification of source of hazards and their causes.	Qualitative (i.e. HAZOP)				
2. Analysis of mechanism of hazard occurrence. 3. Analysis of terminal consequences of hazards.		Qualitative (i.e. HAZOP)			
4. Probability or frequency of a hazard			Qualitative	Usually Qualitative	Mixture of

occurring and thence an estimation of risk.	
5. Judgement of acceptability of risk against social, political or local criteria.	
6. Making decision and establishing ownership of action and monitoring to contain within limits of criteria.	

1. Hazard Identification (Identify sources and causes of hazards).
2. Hazard Analysis (Analyse how hazards will occur and affect).
3. Risk Analysis (Estimate risk i.e. hazard occurring per unit time).
4. Risk Assessment (Compare the risk with acceptable criteria - legal, social or political - and decide whether the risk is lesser or higher than that criteria), and
5. Risk Management (Form organisation to carry out above exercises and to monitor, control, review and keep the risks within permissible limits).

A stage of 'Hazard 'Assessment' is also possible after hazard analysis. When hazard is compared with its standard prescribed e.g. noise level, light, air flow or chemical exposure (TLV, STEL, LD/LC etc.) is compared with their statutory values or Indian Standards and inference is drawn about their difference (measured value- prescribed value), it is called hazard assessment.

4.3 Risk Analysis, Assessment and Management:

Procedure of Risk Management is Stated below which includes Risk Analysis and Assessment.

(A) Five Steps as per HSE (U.K.) guidelines (Qualitative):

1. Look for the hazards.
2. Decide who might be harmed and how.
3. Evaluate the risk and decide whether the existing precautions are adequate or whether more should be done.
4. Record your findings.
5. Review your assessment and revise it if necessary.

These steps suggest simple method of Risk Assessment for any hazardous activity.

It is qualitative only. No factor is quantified. Effect of control measures is taken into account.

(B) Five steps as per Defined Risk Assessment Methodology (Qualitative and Quantitative):

1. Identification of sources of hazards and their causes. It is qualitative, e.g. HAZOP.
   This step is known as "Hazard Identification"
2. Analysis of
   (i) Mechanism of hazard occurrence and
   (ii) Terminal consequences of hazards.
   This is quantitative e.g. HAZAN. Consequence analysis quantifies concentration, deaths, injuries and damage, (e.g. damage distance and effect).
   This step is known as "Hazard Analysis".

3. Probability, frequency or likelihood of hazard occurring and thence an estimation of risk.

This is also quantitative as it depends on failure rates, number of chances or cycles and reliability engineering.

This step is known as "Risk Analysis".

4. Judgment of acceptability of risk against legal, social or political criteria.

Here measured value of hazard or calculated risk is compared with permissible safe limit (e.g. Sell. 2, Factories Act, GPCB norms etc.) and then inference is drawn whether hazard or risk is higher or lower than the permissible safe limit or standard.

Therefore, this is usually quantitative.

This step is known as "Risk Assessment".

5. Decision making and taking control measures to prevent, reduce or transfer the risks, by short and long term planning.

This is a mixture of qualitative and quantitative criteria.

This step is known as "Risk Management".

Risk or Safety Manager should assist the top management in this regard.

(C) Types or Methods of Risk Assessment:

1. Simple or Qualitative Risk Analysis:

It is an identification of hazards and taking appropriate control measures.

It is as per Five steps explained in para (A) above.

Here quantification of hazards and their terminal consequences (damage distances, severity of injury or loss etc.) are not worked out.

It is sufficient to think about the adequacy of existing control measures vis-a-vis hazards identified and to adopt more safety measures if necessary.

Its important aspect is to consider the effect of control measures provided (in place) and to think for the 'Residual Risk' and 'Residual Control Measures' only.

2. Quantitative Risk Assessment:

Here hazard potential is quantified, possible risk is also determined if failure rate data available and then it is compared with the 'permissible standard'. This will indicate whether calculated risk is lower or higher than the permissible limit. Based on this, new control measures or modification in existing control measures can be decided.

Values of following 'Hazard potentials' can be quantified

1. Properties of the material.
2. Storage parameters.
3. Process parameters.

4. Manual exposures.
5. Visible or measured hazards.
6. Transportation hazards.
7. Pollution hazards.

These values give 'severity' part of the risk.

Similarly values of "Control Measures provided" can be quantified depending on the poor controls to the best controls.

Proper classification of good, better and best control measures, is necessary. These values give 'probability' part of the risk.

Then by using the formula. Risk = Severity x Probability, the existing risk level can be calculated and identified as low, high, higher or highest risk.

This method is useful to carry out 'material wise' risk assessment. This method and other methods using ranking matrix are used to carry out 'activity wise' risk assessment also.

3. Other Methods

There are two methods:

(1) Method based on the formula of Risk R = Probability x Severity. This method is mostly useful for assessing risks to workers in the factory. Hazards are considered material wise or activity and sub activity wise.

(2) Method based on computer model. This method is mostly useful for accessing risks to public in vicinity. Gas dispersion models are used and toxic concentration or / and heat radiation [1]ect or / and explosion over pressure effect at different distances (damage distances) are calculated.

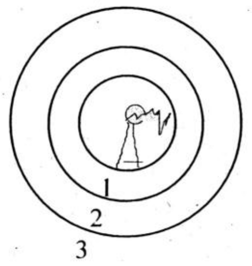
Here it is assumed that if all or some control measures may fail, what would be the highest risk (mostly to public) in terms of toxic effect, fire, explosion or BLEVE effect and at what distances.

This calculation is very complex, needs 'source strength calculation', leak hole or release dimensions, mass released or release rate, wind speed, weather conditions and classification, path obstructions or sinking mechanism, dispersion calculation and use of computer models. Safety, Phast, Aloha, Cirrus, Archie, IIT-Kanpur, Whazan, Effect etc. are such computer models for assessment of this type of risks. Lastly foot prints and risk counters are to be interpreted. Risk counters plotted on geographical plot plan can give Arial view of the area likely to be affected and decision for evacuation or stay-in condition.

Main purpose of this type of risk assessment is to assess the risk to the Public and to make Off-site Emergency Plan based on those risks.

(D) Risk Counters (foot prints):

In case of toxic dispersion, normally three zones are considered. The inner most or zone-I contains the highest concentrations of leaking gas wherein maximum fatality/injury can be predicted. No



entry or no rescue operation may be possible there. Then in intermediate or zone-2, evacuation becomes most necessary and must be carried out at the earliest possible otherwise great fatalities or/and injuries may result. This is the target area of emergency planning and rescue activities. But in doing so, use of necessary personal protective equipment and vehicles is to be done very carefully. The outermost or zone-3 is a safe zone but it can be affected also if dispersion aggravates or lasts for a longer time. Therefore alert and warning action is required in this zone. People must be advised to go away by their own arrangement and should be helped if necessary.

Use of risks counters is useful in On-site and Off-site Emergency Plans for the judgement of area likely to be affected and emergency preparedness for evacuation and other emergency activities.

(E) Risk Control Measures or Elements of Risk Management:

They are as under:

(a) Mission Identification:

1. Establishing risk management policies and procedures.
2. Risk communications.
3. Management of contract portfolios.
4. Claims supervision.
5. Reviewing, monitoring and evaluating the risk management programme.

(b) Risk and Uncertainty Assessment:

1. Hazard, identification.
2. Risk analysis.
3. Risk measurement.
4. Risk assessment.

(c) Risk Control:

1. Risk avoidance.
2. Risk or Loss prevention.
3. Risk or Loss reduction.
4. Information management.
5. Risk transfer. (Contract).

(d) Risk Financing:

1. Risk retention.
2. Risk transfer (Insurance).

(e) Programme Administration:

1. Day to day or short term planning.
2. Long term planning.

Risk Management Activities:

Basic steps of Risk Management are :

1. Identify the Hazards,
2. Analyse the Risk.
3. Select and Evaluate Remedies.
4. Implement any necessary Safeguards.

5. Audit & Review if necessary.

Risk control also includes methods to improve understanding or awareness within an organisation of activities affecting exposure to risk.

Risk reduction activities can be focused On-

1. Altering or modifying the hazard.
2. Altering or modifying the environment in which the hazard exists.
3. Intervening in the processes whereby hazard and environment interact, e.g. fire walls within a structure to separate fire-prone area from other area, shock absorbers to stop transfer of vibrations, silencers to stop transfer of noise, insulation to stop transfer of heat or electricity etc.

If however, risks cannot be controlled, the last resort is to transfer the risk by contract of job or property, or insurance to pay for losses. Risk transfer offers complete protection for the transferor. The burden of risk falls completely on the transferee. In case of accident causing injury, death or damage to property, money can compensate the financial losses but not the pain, suffering and loss to families. Thus risk transfer cannot eliminate all effects of risk. Engineering risk control is the only best remedy.

Risk Managers' duties include

1. Assisting organisation in identifying risks.
2. Implementing risk control programmes.
3. Reviewing contracts and documents (e.g. safety audit, emergency plan, safety reports etc.) including insurance for risk management purposes.
4. Providing education arid training on safety matters.
5. Implementing statutory provisions.
6. Arranging non-insurance financing schemes (e.g. self-insurance or captive insurance subsidiaries).
7. Claims and litigation management.
8. Designing and co-ordinating employee benefit programmes.

4.4 Preliminary Hazard Analysis (PHA) and Hazard Analysis :

This is an initial study to determine hazard causes, effects and controls. Facts of proposed product, process or operation are to be known to determine hazards. For example, for the product using electric power the hazards to be presumed are: electric shock, burns, fire, sparking, hot surface, inadvertent starts of equipment, failure of the equipment to operate at a critical time to cause accident, radiation effects, electrical explosions etc. Similarly adverse effects of foreseeable causes like chemical exposures, reactions, acceleration, mechanical effects, pressure etc. can be listed. Then appropriate remedies are selected and applied.

Since the PHA is fast, cost effective and not complicated like other methods of hazard assessment, it should be adopted as the first step. Its basic steps are as under:

1. Assume a type of accident or hazard possible (e.g. fire, explosion, toxic release, finger cutting etc.)
2. Find out which plant component, system or machine can cause this accident (e.g. storage vessel, reactor, pipeline, circular saw etc.).
3. Find out the event (result) initiating the hazard or accident (e.g. release of explosive or toxic gas, runaway reaction, leakage, running without guard etc.).

This will naturally suggest the corresponding safety devices (safety valve, rupture disc, alarms, gauges, guards, interlocks, trips etc.).

The component system or part in step-2 can then be further examined and analysed for details of failure and how to remove them.

This study indicates which system is more or less important from major hazard point of view and to limit the assessment to priority problems and screening less important ones.

Preliminary hazard identification is required at different stages of project as under :

1. R & D : Chemicals, reactions, impurities and pilot plant.
2. Pre Design : Hazard indices, hazard studies.
3. Design : Process design checks, HAZOP, Failure mode and effects.
4. Commissioning : Safety audits, mechanical commissioning tests, NDT, emergency planning.
5. Operation : Condition and corrosion monitoring.

PHA is generally used for early identification of hazards. It is based on -

Raw materials	Operating environment
Intermediates	Operations
Final products	Other facilities
Plant equipment	Safety equipment etc
Interface among system components.	

For Hazard Analysis see Part 3.35 of Chapter 2. Based on this definition detailed analysis should be carried out.

4.5 Failure Mode and Effect Analysis (FMEA) :

This procedure considers each component of a plant in turn and all possible failure modes and rates and their consequences. The results are recorded in a standard format. HAZOP study is a well developed form of FMEA.

It is a process of hazard identification where all known failure modes of components or features of a system are considered in turn and undesired outcomes are noted.

It is a tabulation of system/plant equipment failure modes. -Each failure mode assigns critical ranking. Human error/ operational error is not generally examined in FMEA.

This is the method derived from reliability engineering. A product or a piece of complex equipment is divided in its components and each component is studied to know how it can fail, at what rate and what could be the effect on it or on the other components. Failure rates of each item are determined and listed. The method is used to determine satisfactory operational life of an equipment, how failures might occur, modes and frequencies of failure and the necessity for proper and timely maintenance and replacements. This knowledge can be used to improve the life and quality of the product. Thus it is primarily more useful to a manufacturer than its user.

FMEA has its own limitations. Data of failure rates and calculations for failure frequency must be correct. The method cannot analyse the problems created by bad design, adverse environment and operators' errors.

FMEA consists of imaginatively Constructing every conceivable situation that could arise with the component, including its designed failure point (life expectancy) and its effect on related components. Considerable imagination with much experience is needed to foresee how a component of the system can cause an unwanted occurrence.

Failure Effect Analysis can be tabulated as under:

Item No.	Assumed Failure	Possible Causes	Symptoms	Consequences
1	2	3	4	5

Compensating provision	Effect on	Probability of occurrence	Failure classification	Remarks
6	7	8	9	10

In above table, compensating provision identifies what should be done to avoid the consequence of the assumed failure.

Probability of occurrence is the average elapsed operating time before a failure of the assumed type will occur.

Probability of occurrence can be expressed in terms of average time between failures as under :

Probable :	1 failure before 10000 hours of operation.
Reasonably Probable :	1 failure during 10001 to 100000 hours of operation.
Remote :	1 failure during 100001 to 10 million hours of operation
Extremely remote :	1 failure after 10 million hours of operation

Failure frequency data is difficult to obtain. It is obtained from two types of testing of component i.e. performance test or reliability test.

Failure classification distinguishes between the possible effects of the assumed failure. A four-part classification is safe, marginal, critical and catastrophic indicating increasing severity.

4.6 Hazard and 0perability(H AZOF) Study:

See Part 3.40 of Chapter-2 'for basic discussion. HAZOP is defined as 'The application of a formal systematic critical examination to the process and engineering intentions of the facilities to assess the hazard potential of mal-operation or malfunction of individual items of equipment and the consequential effects on the facility as a whole'.

In HAZOP a multidisciplinary team searches deviations from design intent through fixed sets of guide words or checklists or knowledge.

HAZOP can be conducted to check the designs or operating procedures for a new project or an existing one. It can also be conducted to improve safety of existing facilities. 'It is also useful before implementing significant modifications or for other operational or legal reasons. After carrying out the Preliminary Hazard Analysis (PHA) as explained earlier, the plant component, system or machine/

equipment part which can cause 'major hazard' becomes known to us. Now to find out deviations or malfunctions leading to such event and its mode of operation, HAZOP helps us. Thus HAZOP is complimentary to PHA.

HAZOP study is carried out to determine deviations from normal operation and operational malfunctions which could lead to uncontrolled events.

Although the HAZOP study was developed to supplement experience-based practices when a new design or technology is involved, its use has expanded to almost all phases of a plant's life. It is based on the principle that several experts with different backgrounds can interact and identify more problems when working together then when working separately and combining their results.

Therefore HAZOP study is performed by a multidisciplinary expert group always including workers familiar with the installation.

The examination procedure takes a full description of the process, systematically questions every part of it to discover how deviations from the intention of design can occur and decides whether these deviations can give rise to hazard.

Each part of design is analysed with questions formulated around a number of guide words, which ensure that the question posed to test the integrity of each part of design will explore every conceivable way in which that design could deviate from design intention and then each deviation is considered for what the consequences it could lead to. The potential hazards are noted for remedial action. Trivial or meaningless consequences are dropped out.

Stages at which HAZOP can be carried out are

1. At an early stage of development to decide the site and identify major hazards.
2. At design freeze stage i.e. when design is completed and construction is to be started.
3. At pre-start-up stage i.e. when construction is completed and the operation is to be started.
4. Studies on existing plants.
5. Studies prior to plant modification.
6. Studies prior to taking a plant, out of service.
7. Studies on research facilities.

Procedure for HAZOP study follows the sequence(1) Define objective and scope (2) Select the team (3) Prepare for the study (4) Carry out the examination (5) Follow up and (6) Record the results.

The objectives may be (1) to check a design (2) to decide whether and where to build (3) to decide whether to buy an equipment (4) to obtain a list of questions to put to a supplier (5) to check running instructions and (6) to improve the safety of existing facilities etc.

The team may be composed of Mechanical Engineer, Chemical Engineer, R & D Chemist, Production Manager, Project Manager, Instrument/ Electrical Engineers, Civil Engineer etc. The team should not be too large. The team is headed by an experienced specialist from works management or by a specially trained consultant.

After examining one part of the design and recording potential hazards if any, the study proceeds to examine the next part of the design and it is repeated until the whole plant has been studied.

The Preparative Work includes four stages (1) Obtain the data (2) Convert the data into a suitable form (3) Plan the sequence for the study and (4) Arrange the necessary meetings.

After discovery of a hazard, follow-up action becomes necessary. There may be a number of possible actions. Generally they are of four types :

1. Change in the process (material, recipe etc.).
2. Change in process conditions (pressure, temperature, flow etc.).
3. Alteration to the physical design including safety guarding.
4. Change of operating methods.

While choosing between such possible actions, two categories become relevant :

1. Those actions which remove the cause of hazard.
2. Those actions which reduce the consequences.

Obviously the first category is first preferable. But then the study should be carried out at design stage to execute it at the minimum cost and better integrity.

Suppose the hazard is 'sudden evolution of gas and pressure due to it'. For this, four actions are possible -

1. Change the material to eliminate the possibility of gas generation.
2. Change the process condition (e.g. cooling, catalyst, low temperature, temperature control and Cut off etc.) to control the gas generation.
3. Provide safety valve/rupture disc and vent for safe discharge.
4. Provide personal protective equipment.

Action-I is 100% effective and should be die first choice. Action-2 may be selected, if Action-1 is not possible and reliability of the control system is good. Action-3 may be selected, if Action-2 is not possible and effective only if the vent and dump-vessel can be designed to cope with the full discharge. Action-4 is the last resort if Action-I, 2, 3 are not possible or not effective.

Recording needs 'hazard file' containing

1. Copy of the data as under :.
   (1) Process description, process flow diagram, material and enthalpy balances.
   (2) Piping and instrumentation diagrams.
   (3) Process equipment layouts - plan, elevation and section.
   (4) Operating manual.
   (5) Safety manual.
   (6) Vendor information (P & I diagrams).
   (7) Equipment specification sheets.
   (8) Piping specifications.
   (9) Plot plan.
   (10) MSDS for materials.
   (11) Any reports on safety reviews.

Copies of such documents should be marked by the team leader slating that they are examined.

2. Copy of all the working papers, questions, recommendations, redesigns etc. produced by the team and others as a result of the study.

The file should be retained on the plant and a report be prepared for the guidance of the managers.

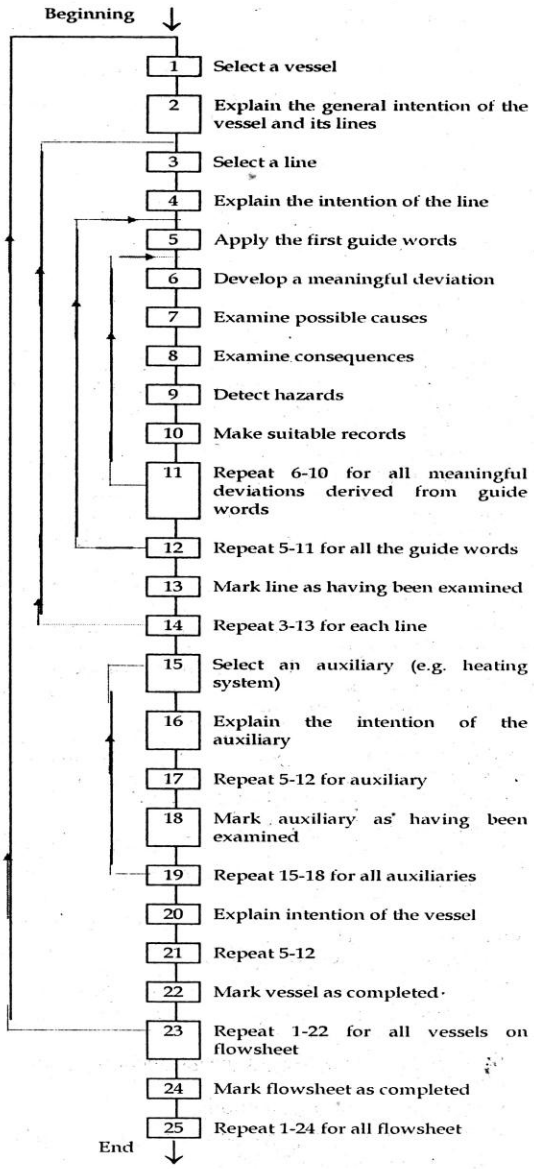
Guidewords used in HAZOP are given below.

A List of some Guide Words

Guide Words	Meanings	Comments
NO or NOT	The complete negation of these intentions	No part of the intentions is achieved but nothing else happens.
MORE LESS	Quantitative increases or decreases	These refer to quantities + properties such as flow rates and temperatures as well as activities like 'HEAT' and 'REACT'.
AS WELL AS PART OF	A qualitative increase A qualitative decrease	All the design and operating intentions are achieved together with some additional activity. Only some of the intentions are achieved; some are not.
REVERSE OTHER THAN	The logical opposite of the intention Complete substitution	This is mostly applicable to activities, for example reverse flow or chemical reaction. It can also be applied to substances, e.g. 'POISON' instead of 'ANTIDOTE' or 'D'' instead of 'L' optical isomers. No part of the original intention is achieved. Something quite different happens.

A Sequence of Study proceeds as follows.

Sequence of HAZOP Examination



Various methods for HAZOP studies are described by DOW Safety Guide, HAZOP studies by ICI, by Chemical Industry Safety and Health Council (CISHC), by Kletz, Gibbsen, Lawley and other experts. The basis of studies may be a word model, a process flow sheet, a plant layout, fault free technique etc.

See Reference No. 29 for more details.

4.7 Hazard Ranking (DOW & MOND Index):

This is a method of identifying and ranking of hazards present in a process plant. It was developed by Dow Chemical, USA and is usually known as Dow Fire and Explosion Index. ICI improvement on this is known as Mond Index.

The index provides weightage for inventory, flammability, reactivity, toxicity and hazards due to reaction exotherm, operating condition, corrosivity, plant drainage, access, rotating equipment, leaky joints etc.

The ranking indicates damage radius, maximum probable property damage (MPPD) and maximum possible days outage (MPDO).The ranking is useful for decision making, for example, it shows why protection is more extensive in LPG storage sphere than LPG reflux drum.

DOW and MOND Index:

Various hazard indices have been developed to (1) Qualify the expected damage due to fire, explosion or toxicity (2) Identify the equipment that would create or escalate an accident and (3) Communicate such risk potential to management to take necessary remedial measures e.g. increasing separation distance, erecting a blast wall or fireproof construction and revision of fire fighting and gas control facilities. '

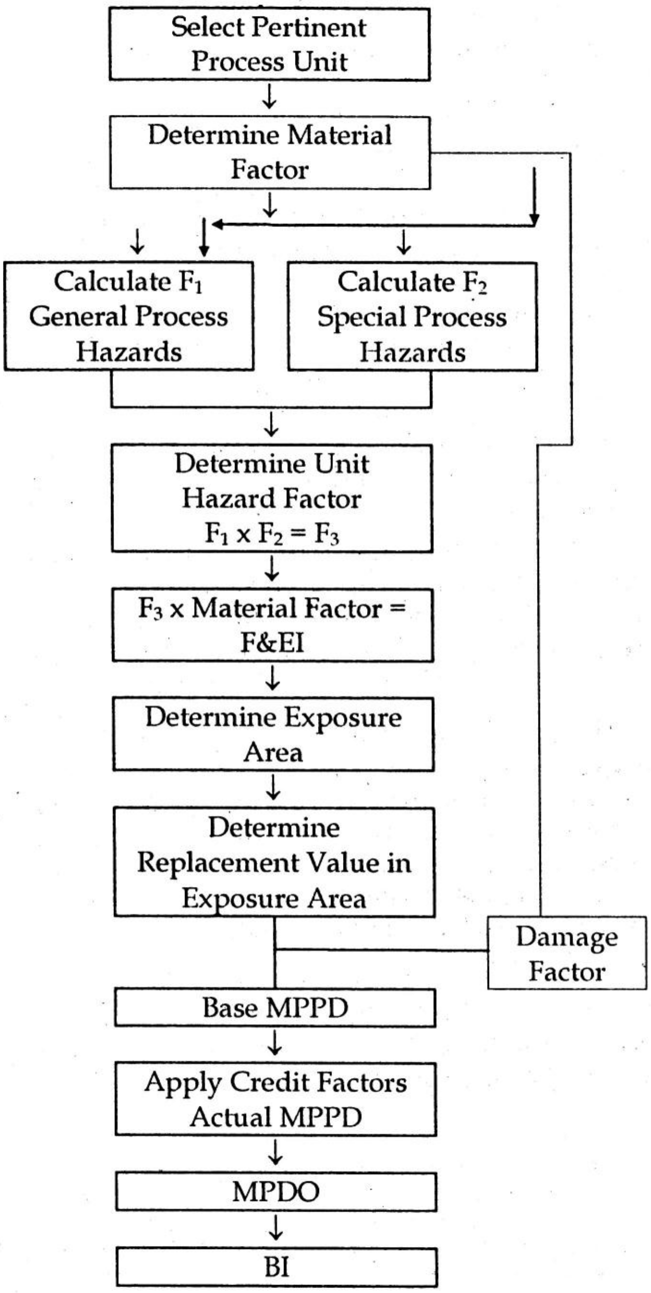
The most famous and widely used hazard index is the Dow Index developed by the Dow Chemical Company of USA since 1964. The MOND Index is an extended Dow Index based on the similar methodology with an useful extension e.g. to estimate fire load of an area and a unit toxicity index.

In the first three editions the methods of determining the Fire and Explosion Index (F & El) were developed and in the fourth edition, the method of calculating Maximum Probable Property Damage (MPPD) from the F & El was suggested and a Toxicity Index (n) was introduced. For details the Company's Guide has to be referred.

To develop an F&EI and risk analysis summary, we need -

1. An accurate plot plan of the plant.
2. A process flowsheet.
3. An F& El Hazard Classification Guide.
4. An F& El Form.
5. An Unit Analysis Summary.
6. A Plant Risk Analysis Summary, and
7. A cost data for the installed process equipment under study.

A schematic diagram of procedure to calculate F & El, MPPD, MPDO (Maximum Probable Days Outage) and BI (Business Interruption loss) is shown below.



As revealed from the figure, the procedure for assessment is summarised as under

1. Identify on the plot plan any Process Units that are considered pertinent to the process and that would have the greatest impact on the magnitude of a fire or explosion.
2. Determine the Material Factors (MF) for each process unit. It can be calculated from flammability and reactivity, or from its ready table (some figures are given below).
3. Evaluate each of the contributing hazard factors listed on the F & El Form, under 'General Process Hazards' and 'Special Process Hazards' and apply the appropriate penalties. This will give F_1 and F_2.
4. Unit hazard factor $F_3 = F_1 \times F_2$. This gives the degree of hazard exposure of the process unit. From the chart, using unit hazard factor with the MF to determine Damage Factor (DF) which represents the degree of loss exposure.
5. F & El = MF x F,. From the chart, by using F & El, Area (radius) of Exposure surrounding the process unit can be determined.

6. Determine the Rupee value of all equipment within the Area of Exposure. This value is used to obtain the Base maximum Probable Property Damage (Base MPPD).
7. The Base MPPD can be reduced to an actual MPPD by applying various Credit Factors and/ or 'by relocating certain high value equipment outside the Area of Exposure.
8. Actual MPPD is used to obtain MPDO, from which Business Interruption (BI) can be calculated.

Material Factor (MF) is the basic starting value in the computation of the F & El and other risk analysis values. It is a measure of the intrinsic rate of potential energy release from fire or explosion produced by combustion or chemical reaction.

The MF is obtained from N, and N, the NFPA signals expressing flammability and reactivity (or instability) of a material at ambient temperatures. As fire and reaction hazards increase with temperature, 'Temperature Adjustment of MF' is also required. In case of mixture, normally the MF of the component with the highest MF value is considered.

The MF is a number in the range from I to 40 and higher number indicates higher hazard. MF and Heat of combustion H_C of some common chemicals are given in following table :

MF & H_C Values

Chemical	MF	HcBTU/lb
Acetaldehyde	24	10500
Acetone	16	12300
Acetonitrile	24	12600
Acetylene	29	20700
Acrylonitrile	24	13700
Ammonia	4	8000
Benzene	16	17300
Bromine	1	0
Butane	21	19700
Carbon disulphide	16	6100
Carbon monoxide	21	4300
Chlorine	1	0
Ethyl alcohol	16	11500
Ethylene	24	20800
Ethylene oxide	29	11700
Formaldehyde	21	8000
Gasoline (petrol)	16	18800
Hydrogen	21	51600
Hydrogen sulphide	21	6500
Methyl alcohol	16	8600
Naphtha	16	18000
Nitrobenzene	10	10400
Nitro-glycerine	40	7800
Phenol	10	13400
Sulphur	4	4000
Sulphur dioxide	0	0
Toluene	16	17400
Vinyl chloride	21	8000

Xylene	16	17600

In the above table higher MF indicates high hazard potential and higher H. indicates high heat generation while burning, which in turn, indicates more quantity of fire fighting material (e.g. water, foam, DCP etc.) and equipment. MF for dusts is determined by different methods.

The Toxicity Index is used to evaluate process exposure level for toxicity hazard and is defined as -

$$Tl = \frac{Th}{100} \quad \frac{(P+S)}{100}$$

where T_h is the factor for the most hazardous material present in appreciable quantity with the lowest TLV, P the total GPH (General Process Hazards) penalties used and S the total SPH (Special Process Hazards) penalties used.

T_h can be known from the NFPA health rating N, as under

N_h	T_h
0	0
1	50
2	125
3	250
4	325

Assessment from Index : The degree of hazard potential can be determined from the value of F &: El as under:

F & El Range	Degree of Hazard
0 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 & above	Severe

Example : Suppose General Process Hazard factor F_1 and Special Process hazard factor F_2 have been calculated as 2.8 and 3.8 respectively. Then with a MF 24 for acrylonitrile (ACN), the F & EI value is F_3 x MF – F_1 x F_2 x MF - 2.8 x 2.8 x 24 = 255. As it is above 159, it indicates severe hazard.

Based on F & EI and toxicity index TI, following categories are available:

Category	**F & EI**	**TI**	**Degree of Hazard**
I	F<65	T<6	Low
II	65<F<95	6<T<10	Medium
III	F>95	T>10	High

Fire Potential can also be assessed if the Fire Load F (BTU/ft^2) for particular area is known (calculated). Then a range of expected fire duration and hazard categories can be assessed from following table.

Fire load. Duration & Hazard Category

Fireload F in BTU / ft^2 of normal working area x 103	Range of expected fire duration in hours	Hazard category	Example
0-50 50-100 100-200 200-400 400-1000 1000-2000 2000-5000 5000-10000	0.25-0.5 0.5-1 1-2 2-4 4-10 10-20 20-50 50-100	Light Low Moderate High Very high Intensive Very extreme	Buildings Dwellings Factories Occupied Buildings Rubber 100-Ware- houses

Explosion Potential can be known from the following table if Internal Plant Explosion Index 'E' or Aerial Explosion Index 'A' is known.

Category	E	A
Light	0-1	0-10
Low	1-25	10-30
Moderate	2.5-4	30-100
High	4-6	100-500
Very high	>6	>500

Thus by knowing the hazard potential categories, inter-unit separation distances and unit boundary distances can be determined from the following tables.

Inter Unit Boundary Distances

Unit 'A' of Reduced Dow F & EI	Minimum distance in Meters to Unit 'B' having Reduced Dow F & EI of					
	Mild	Light	Moderate	Moderately Heavy	Heavy	Extreme
Mild	0	5	6	8	10	12
Light	5	6	8	10	12	15
Moderate	6	8	10	12	15	17
Moderately heavy	8	10	12	15	17	20
Heavy	10	12	15	17	20	25
Extreme	12	15	17	20	25	30

Within Unit Boundary Distances

Unit Reduced Dow F & EI	Minimum distance in Meters to		
	Works Boundary	Plant Boundary	Offices, Amenities Control Rooms etc.
Mild	20	15	10

Light	25	20	12
Moderate	30	25	15
Moderately heavy	40	30	20
Heavy	50	35	30
Extreme	75	50	45

It should be borne in mind that all such assessment and distances are approximation and suggest a minimum guideline. The complex computation method has its own limitations. DOW index cannot predict probability of hazard occurring. Corrosion and leakage have special effects. Reactions difficult to control, operation in or near flammable range and greater than average explosion hazard certainly contribute to high risk category.

Revised DOW index model is also available.

4.8 Fault Tree Analysis (FTA) :

It is a method to represent the logical combinations of various systems which lead to a particular outcome (top event).

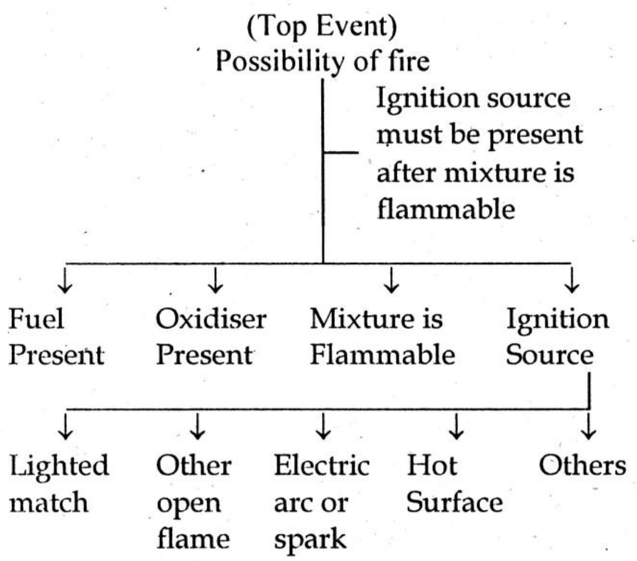
It is a graphic model that determines various combinations of equipment faults and failures that can result in an accident.

This is a sophisticated form of reliability assessment and it requires considerable time and skill. The procedure is to start from a selected undesirable top event such as 'gas coming out of a scrubber' and then trace it back to the combination of faults and conditions which could cause the events to occur. Apart from identification of hazards, it is widely used for quantitative risk analysis. It will be necessary to obtain meaningful failure data of each component to arrive at the frequency of occurrence of the 'top event'.

In fault tree analysis, abnormal operations are assumed in normal operations of a plant. The ultimate abnormal event (such as gas leakage) is shown in a rectangle at the top. Then all combinations of individual failures that can lead to that abnormal event are shown in the logical format of the Fault Tree. By estimating the individual failure probabilities and then using the appropriate arithmetical expressions, the probability of the top abnormal event can be calculated or predicted. This Fault Tree Analysis makes it easy to investigate the impact of alternative preventive measures. Fault tree is developed from top to bottom through a series of symbols which define the flow of logic from the base causes of an event itself. Detailed' probability data are most desirable.

This method of Fault Tree Analysis was developed by Bell Laboratories (USA) in 1961 to predict potential catastrophic events which could occur with the Air Force. It is more useful to assess chemical hazards.

Without specific Fault Tree symbols (symbology), a schematic diagram of one top event (possibility of fire) is shown below.



Some sample top events for Fault Tree Analysis are

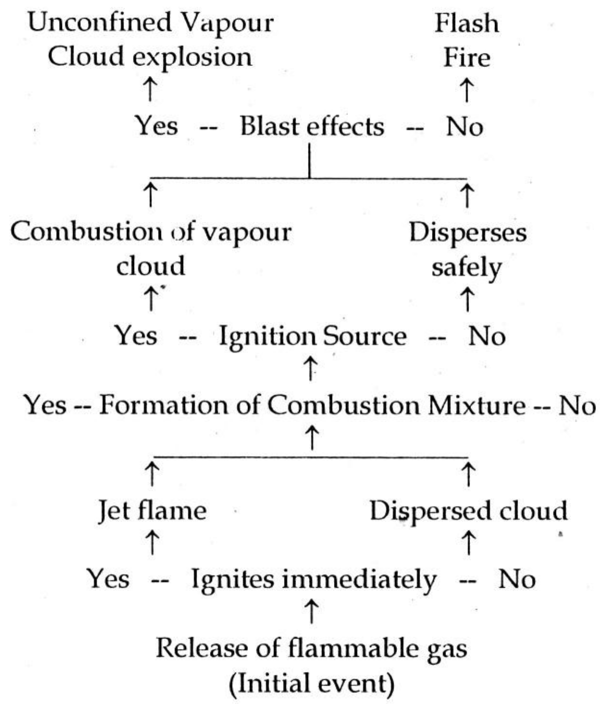
1. Injury to ___________
2. Damage to ___________ from ___________
3. Explosion of ___________
4. Loss of control of ___________
5. Rupture of______
6. Loss of pressure in ___________
7. Overpressurisation of ___________
8. Unscheduled release of ___________
9. Collapse of ___________
10. Overheating of___________
11. Uncontrolled venting of ___________
12. Inadvertent start of etc. ___________

A computer is much useful to carry out mathematical Fault Tree calculations using Boolean algebra.

4.9 Event Tree Analysis (ETA) :

Event tree analysis is a method to illustrate the intermediate and final outcomes which may arise after the occurrence of a selected initial event.

This technique is complementary to Fault Tree, but in reversed direction. Whereas a fault tree starts from a final event and works from the top down, an Event Tree begins with an initial event such as a power failure and explores all possible outcomes by working from the bottom up. An illustration is shown below, for an initial event of release of flammable gas.



ETA identifies the sequences of events following an initiating event that results in accident. Event tree considers operator response or safety system response to the initiating event in determining the potential sequence.

Some sample initial (bottom) events for Event Tree Analysis are :

1. Failure of pump of____
2. Failure of stirring of ____
3. Failure of water/cooling media/heating media in ______
4. Stoppage of motor at ____
5. Mistake of____

4.10 Accident or Cause Consequence Analysis :

Cause-Consequence Analysis identifies potential accident consequences and the basic causes of these accidents.

Any hazard or risk assessment is incomplete if the consequences of a possible accident are not known. Therefore the last step in hazard assessment is to analyse the consequences that a potential major (credible) accident may-cause on the plant itself, on die workers, on the surrounding and on the environment. Therefore an accident consequence analysis should contain

1. Cause of the accident (fire, explosion, rupture of a vessel, pipe, valve etc.).
2. Estimate of the mass released (flammable, explosive, toxic quantity).
3. Calculation of the dispersion of the material released and the damage distance, (liquid, vapour or gas).
4. Estimate of the effects (heat radiation, blast wave, toxic, degree of burn, severity etc.).

1 & 2 can be known by using the results of the hazard assessment while mathematical models have to be applied in finding 3 & 4. See Part 4.12 for effect of 2,3,4 above.

The results of ACA can be used to select necessary PPE, FFE, alarm or pressure relief device. It is also useful in deciding plant siting and layout and emergency planning in addition to risk assessment.

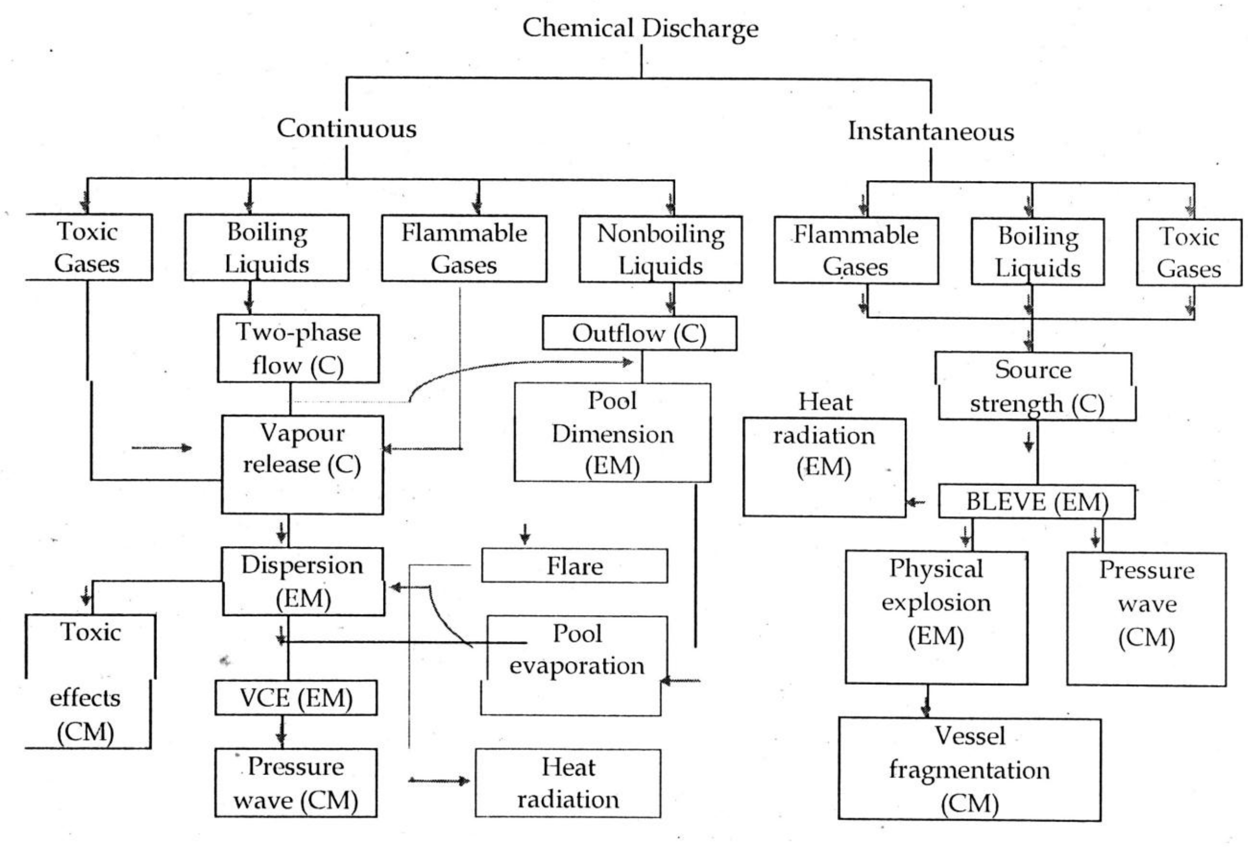
However higher estimates may lead to unnecessary additions to a plant and excessive capital cost. Therefore it is advisable that a company using such quantitative risk analysis should use its own experience and judgement to define targets for comparing the results.

The effects after accidental release of a chemical depend on many factors like type and quantity of the released chemical, meteorological conditions; topography, location or presence of ignition source. The accident scenarios can be divided into different categories such as

1. Liquefied gas or boiling liquid release under pressure (e.g. LPG)
2. Flammable/explosive gas release (e.g. H)
3. Toxic gas release (e.g. CL,)
4. Non-boiling liquid release (e.g. benzene)

Following figure shows the typical chemical discharge modes and their linkup to show their effects (radiation, explosion, toxic release etc.) Consequence analysis considers physical effects and damage caused by them. A combination of different discharge effects should also be considered.

Different Discharge Modes to Consider Consequence Analysis Chemical Discharge



C = Calculation, CM = Consequence Model, EM = Effect Model

Extensive data are to be collected during preliminary MCAA. It includes physical, chemical, thermodynamic, transport and safety properties of hazardous chemicals, process units and overall layout of the chemical plant and meteorological and demographic conditions. Subsequently the integrity of the process and storage units, process activities and work culture at each site are to be assessed. .

Overflow models calculate the source strength of the released material. Post-release phenomena (fire, explosion or toxic dispersion) can be quantified with the help of computer software packages based on mathematical models given below. Gaussian model is useful for neutral density (lighter) gases while other models (e.g. 3D) arc also available for heavy gas dispersions.

Mathematical models for consequence analysis

Sr. No.	Phenomenon	Application models
1	*Outflow*	
	Liquid Two phase mixtures Gas/vapour	Bernoulli flow equations; phase equilibria; multiphase flow models; Orifice/nozzle flow equations; Gas laws; Critical flow criteria.
2	*Discharges*	
	Spreading liquid	Spreading rate equations for non penetrable surfaces based on cylindrical liquid pools.
	Vapour jets Flashing liquids	Turbulent: free jet model. Two zone flash vaporisation model.
	Evaporation of liquids on land and water	Spreading boiling and moving boundary heat transfer models; Film and metastable boiling phenomenon; Cooling of semi-infinite medium.
3	*Dispersions*	
	Heavy Gas	(i) Buoyancy dominated, stably stratified and passive dispersion models (similarity). (ii)3D models based on momentum, mass and energy conservation.
	Neutral Gas	Gaussian dispersion models for neutrally byoyant plumes.
	Atmospheric stability	Boundary layer theory (turbulence); Gaussian distribution models:
4	*Heat radiation*	
	Liquid pool fires	Burning rate, heat radiation and incident heat correlations (semi-emperical); Flame propagation behaviour models.
	Jet fires Fireballs	Jet dispersion models API fireball models relating surface heat flux of flame, geometric view" factor and transmission coefficients.
5	*Explosions*	
	Boiling liquid expanding vapour clod explosion	Fireball and physical overpressure models, Deflagration and detonation models; ID gas dimensional computations.

6	*Vulnerability*	Probit functions; non-stochastic vulnerability models.

Criteria for heat radiation, explosion and toxic effects can be used to classify the accident scenarios for further investigations and to calculate effect and damage for primary events. Such damage criteria are as under :

Damage Criteria

Heat Radiation		**Explosions**		**Toxic Gas Dispersions**
Incident Flux kw/m^2	**Damage**	**Peak over pressure, bar**	**Damage**	**Damage**
37.5	100% lethality; Heavy damage to equipment	0.3 0.1	Heavy (90%) Repairable (10%)	The extent of damage depends upon the concentration of the toxic compound in the atmosphere; the relation between percent of injuries and the toxic load is normally given in the form of Probit Functions.
25	100% lethality; nonpiloted ignition	0.03 0.01	Damage of glass Crack of windows	
12.5	100% lethality; piloted ignition			
4	Not lethal; 1st degree burns			
1.6	No discomfort even after long exposure			

Past accidents provide useful clues and supporting information for the effect and damage calculations. Data bank TACTS' of past accidents is available from TNO. The Netherlands has vital information of more than 15000 chemical accidents that occurred in various parts of the world. Such databank of accidents in our country can be developed by NSC or LPA.

4.11 Maximum Credible Accident Assessment (MCAA) :

See Part 3.100 of Chapter-2 for definition.

MCA means maximum credible accident i.e. an accident with a maximum reasonable damage distance possibility.

MCAA means maximum credible accident analysis or assessment. Here probability of accident occurrence is not calculated but the probability of maximum damaging effect (potential and distance) is calculated to assess injury to people or/and properties in the surrounding area.

Hazard potentiality is considered by (1) Type of material stored/processed (toxicity, flammability etc.) (2) Quantity of the material (it affects distance) (3) Process or storage conditions (temperature, pressure, flow etc.) (4) Location of the unit or activity with respect to adjacent population.

Based on above factors, units/activities are selected, accident scenarios established and effect (domino or cascade) and damage calculations are carried out.

Following steps are employed in MCAA :

1. Chemical Inventory Analysis.
2. Identification of hazardous processes in individual units.
3. Identification of chemical release and accident scenarios.
4. Data acquisition for MCAA.
5. Effect and damage calculations for the primary events'
6. Analysis of past accidents of similar nature.
7. Short listing of maximum credible accident scenarios.

These steps are explained below in brief.

The chemical inventory is to be identified by MSIHC Rules or Rule 68 J of the Gujarat Factories Rules (see Part 10.8 of Chapter-28), short listed and prioritised on the basis of hazard potential. The chemicals are generally classified as non-boiling and boiling liquids, gases/vapours and solids.

Hazardous processes- are also identified by above statutory provisions. Runaway reactions need due consideration during preliminary MCAA.

4.12 Vulnerability Analysis :

Vulnerability is the susceptibility of life, property and the environment to injury or damage if a hazard manifests its potential.

The vulnerability analysis identifies what part of the community is susceptible to more damage if a hazardous substance releases. It provides information on :

1. Vulnerable zone (affected area) for a spill or release and the conditions that affect the zone (wind speed & direction, size of release).
2. Population, in terms of size (density) and types (residents, workers, sensitive population hospitals, schools, nursing or care centres, old men's shelter, prisons, spectators in auditoriums or stadiums) lying within the vulnerable zone.
3. Private and public property (homes, offices, businesses) that may be damaged, including essential support system (water, milk, food, fuel, power, medical) and transport centres, and
4. Environments (land, air, water, crops, food, vegetable, animal habitats, livestock etc.) that may be adversely affected and impact on sensitive natural areas and endangered species.

To get information on 1 (i.e. vulnerable zone) mathematical and computer models or probit equation can be used. To get information on 2,3, & 4, following steps are useful -

1. Survey of the area (first hand information by driving through the area).
2. Interviews of fire, police, emergency and planning department personnel.
3. Review of planning department documents and statistics on land use, population, highway usage and the area's infrastructure.

By consequence analysis damage or physical effects resulting from the release of hazardous substances can be determined while by vulnerability analysis such effects (consequences) can be translated in terms of injuries and damage to exposed people, property and environment. All such exercises are useful for emergency planning (i.e. on-site and off-site emergency plans).

In estimating size of vulnerable zones following variables arc considered :

1. Quantity and rate of release to air. This depends on (a) Total quantity released (b) Physical state (solid, liquid, gas) and (c) Conditions (pressure, temperature) of storage or handling.
2. Meteorological conditions.
3. Surrounding topography.
4. Level of Concern (LOC) i.e. the concentration of an extremely hazardous chemical (EHS) in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time.

   No precise measure of LOC is available. Different guidelines suggest different values. It is to be estimated from IDLH, LC/LD, TLV, STEL and other permissible values. Rough estimation is as under -

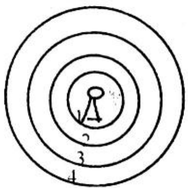
   Estimated IDLH = LCL_0, or
   = LC_{50} x 0.1, or
   = LCL_0 x 0.1, or
   = LC_{50} x 0.01

   Then LOC = 0.1 x estimated IDLH or direct IDLH available.

   $$\text{LOC (in gm/m}^3\text{)} = \frac{\text{LOC (in ppm)}}{1000} \times \frac{\text{MW}}{24.5}$$

   Note : IDLH immediately dangerous to life & health, LC=lethal concentration (gas), LD=lcthal dose (solid or liquid), TLV=threshold limit value, STEL=short term exposure level and MW=molecular weight. See Part 6.9 of Chapter24 for details.

5. Estimating vulnerable zones for initial screening and revaluation of the estimated zones as shown below.



It is important to mention that different assumptions or conditions give different radius of estimated vulnerable zones as shown in the figure.

The four circles differ as under -

1. Selection of higher LOC.
2. Use of higher wind speed and less atmospheric stability. -
3. Small quantity and less rate of release.
4. Radius for initial screening zone.

Calculations should be based on credible worst case assumptions and considering wind speed, stability class and chemical toxicity. Instantaneous and continuous releases including spills, leaks, fires, explosions and BLEVE should be considered. Multiple point sources operating concurrently may be considered. Gaussian or other models (see Part 14.2 & 14.3 of Chapter-18) may be used depending on prevailing conditions. Site effects of terrain are relevant. The results of the calculations should be represented in graphical format.

Use of Probit Equation :

The probit function is given by

$P = K_1 + K_2 + \text{Log}C$

where P = Probit, a measure for the percentage of people exposed who incur a particular injury (for conversion table from probit to percentages see Part 6.2.3 or Reference No. 27), K_1 = a constant depending on the type of injury or type of load or causative factor C and K_2 = a constant depending on the type of load C.

For toxic release calculations, probit equation is given by -

$$P = K_1 + K_2 \text{Log}(C^n t)$$

where C = concentration of the toxic substance in mg/m^3, t = the exposure time in minutes and K_1, K_2 and n are constants depending on the toxic substance.

For example, these values for three main gases are given as :

Chlorine, $P = -10.29 + 0.92 \text{ Log } (C^2 t)$
Ammonia, $P = -27.27 + 2.27 \text{ Log } (C^{1.36} t)$
SO_2 $P = -17.73 + 2.10 \text{ Log } (Ct)$

These equations estimate that in case of chlorine, death will occur in 50% of the persons exposed to a concentration of 1050 mg/m^3 at an exposure time of 15 minutes and in case of SO_2, 1% mortality will occur to a concentration of 550 "g/ 3 at 30 min exposure time.

Fire : For heat radiation calculations, probit equation is given by –

For lethality, $P = -36.38 + 2.56 \text{ Log } (C^{4/3} t)$
For first degree burn,
$P = -39.83 + 3.0186 \text{ Log } (C^{4/3} t)$

where,
C = thermal load W/m^2 and t = exposure time in seconds. The values given are for unprotected body. If people are wearing clothes, injuries are assumed to be reduced by a factor of 7.

See Part 6.2.3 for further discussion.

Explosion : A pressure wave caused by BLEVE or gas cloud explosion will make probable damage as under:

Peak over pressure (bar)	Type of damage
0.01	Windows smashed.
0.03	Damage by flying fragments of glass.
0.1	10% of houses seriously damaged.
0.3	90% of houses seriously damaged.

A peak overpressure of 0.1 bar is taken as the limit for fatality and 0.03 bar as the limit for causing wounds. Within the zone of a peak overpressure of 0.3 bar, the risk of death in houses is I in 80 people.

Thus vulnerable analysis employs scientific assumptions and calculations to estimate damage zones and number of people likely to be affected. Emergency planning is not possible without such efforts.

4.13 What if Analysis :

The method involves possible deviations from die design, construction, modification, or operating plant. A question 'What if is asked, e.g. What if wrong material is charged? What if pump stops functioning?

This method identifies possible accident event sequences and thus identifies the hazards consequences and steps for risk reduction. -

5 RELIABILITY ENGINEERING

Hazard control technology mostly involves the probabilistic methods to detect failure possibilities and accidents. Reliability engineering is a branch concerning this aspect.

Various topics on reliability engineering include statistics, mathematics, set theory, failure rate and analysis, unreliability, availability, failure distributions including exponential, binomial and lognormal distributions etc., repair and maintenance, scries, parallel and standby systems, Marcov models, Monte Carlo simulation graphs, diagrams and flow sheets and computer programmes.

Application of reliability engineering in process industry is very wide. It is applicable to mechanical, electrical and instrument systems, critical equipment and devices, nuclear systems, quality control, analysis of faults and abnormal occurrences, repair and maintenance etc.

5.1 Principles of Reliability Engineering:

IS.-10139 on presentation of reliability, maintainability and availability predictions and IS:8161 (II Parts) on guide for equipment reliability testing are most relevant. Reliability of electrical/electronic equipment and performance data is given in IS:7354 (6 Parts), 8607 (Part-8) and 1885 (Part 39) electro technical vocabulary - reliability of electronic and electrical items. IS:8161 guide for equipment reliability testing, Part-1 is for principles and procedures and out of total II parts. Parts 6 & 7 are on tests for validity of constant failure rate assumption and meantime between failures. They should be referred for details.

Reliability is defined as the probability that an item will perform a required function under stated conditions for a stated period of time.

Thus reliability depends on probability, time and failure, I;ailure may be due to failure in operation (e.g. equipment in continuous service) or failure to operate on demand or failure to operate before or after demand (e.g. equipment operating intermittently).

Probability P of a particular event is

$$P = \lim_{n \to \infty} \frac{\text{Number of occurrences of the event}}{\text{Total number of trials (n)}}$$

Thus if fire happens 5 times when trials (n) to cause it are made 10 times, the probability is 0.5, or

$$P = \frac{\text{Lim}}{n \rightarrow \infty} \quad \frac{5}{10}$$

If an equipment fails 3 times when total operations (chances to fail) happened 1000 times, the probability or failure rate is said to be of 0.003.

If a person falls 2 times when he climbs a particular staircase 100 times, the probability of falling or the falling rate is said to be of 0.02.

Reliability - R(t) of an element or system can be defined as the probability that the element or system will operate to an agreed level of performance, for a specified period, subject to specified conditions.

In a measurement system 'agreed level of performance' could mean, for example, an accuracy of 1.5%. If the measurement system is giving error more than this, it is considered to have failed, even though it is otherwise working normally.

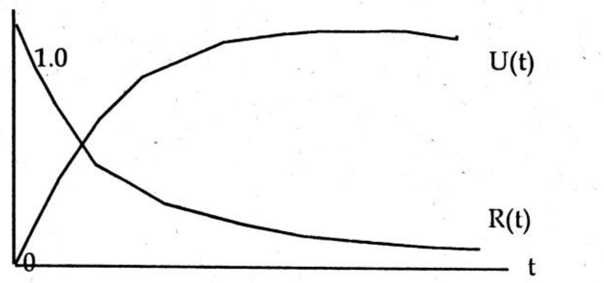
Reliability varies with fane. A system just checked and calibrated should have a reliability of I when placed in service. After a year the reliability may be only 0.5 as the probability of failure increases.

Unreliability U(t) can be defined as the probability that the element or system will fail to operate to an agreed level of performance, for a specified period subject to specified conditions.

The sum of reliability and unreliability must be unity, i.e.

$$R(t) + U(t) = 1$$

See following figure for this relationship.



Variation of reliability and unreliability with time for constant failure rate and no repair.

Unreliability also depends on time. A system just checked and calibrated should have an unreliability zero, when first placed in service but it may increase to say 0.5 in few months.

Mean Time Between Failure (MTBF) is applicable to any type of equipment whose faulty component or unit can be replaced or repaired. Suppose N identical elements or systems are tested for a total period T years. Each fault is recorded, the equipment is repaired, put back into service and the total number of faults F during T found. Then

$$MTBF = \frac{NT}{F_N}$$

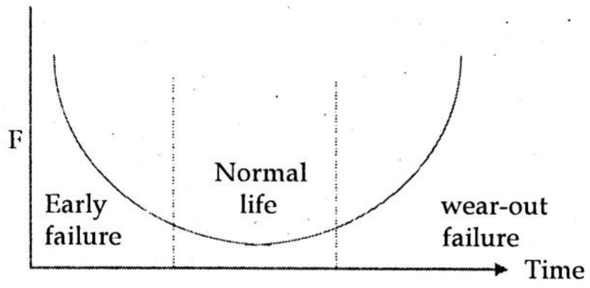
where the test interval T does not include the total repair time. Thus if 50 faults are recorded for 100 differential pressure transducers over 2 years, the

$$MTBF = \frac{100 \times 2}{50} = 4 \text{ years}$$

Failure rate - F is the average number of faults per item of equipment, per unit time. It is mostly constant over much of their working life and therefore reciprocal of MTBF i.e.

$$F = \frac{1}{MTBF} = \frac{F_N}{NT}$$

The failure rate varies throughout the life of the equipment shown as under.



Variation in Failure rate (bathtub curve)

Three phases - early failure, mature failure (normal working life) and wear-out failure give bathtub curve as shown in the figure. The early failure region, lasting normally for 6 months, is due to weak components and unfamiliarity in operating the system. The mature region, lasting possibly 10 years, is characterised by a low constant failure rate, all weak components have been removed from the system and the system is being operated correctly. The wear-out region is characterised by an increasing failure rate as components reach the end of their .working life.

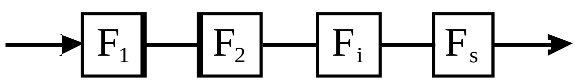
Relationship between R(t), U(t) and F is given by

$$R(t) = \frac{n_s}{n_o} = e^{-Ft} \quad \text{and} \quad U(t) = \frac{n_f}{n_o} = 1-e^{-Ft}$$

where $n_s = n_o - n_f$ = number of items still serviceable,

n_o = items of equipment set in operation at time $t = 0$, n_f = items survive after time t.

Reliability of a system in series is shown in Fig. 19. Here S elements of a system are in series with failure rates F_1, F_2, F_i, F_s. The system will only survive if each clement survives.



Reliability of a system in series

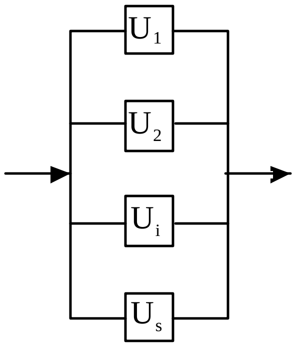
If one element fails then the system fails. Assuming that the reliability of each element is independent of the other elements, then the system reliability is the product of the element reliabilities i.e.

$$R_{syst} = R_1 R_2 ... R .... R_s$$
$$= e^{-F1t} \times e^{-F2t} \dots e^{-Fit} \dots \times e^{Fst}$$
$$= e^{-Fsyst} = e^{-(F1+F2+..Fi..+Fs)t}$$

and $= F_{sys}t = F_1 + F_2 + ..F_i.. + F_s$

where F_{sys} is the overall system failure rate and F_1 F_2. F_s are individual failure rates of S elements.

Reliability of a system in parallel is shown below. Here S systems are in parallel with their unreliabilities U_1, U_2, Ui, Us.



Reliability of 'S' systems in parallel

The overall systems will only fail if every individual system fails. Assuming that the unreliability of each system is independent of unreliability of the other systems, the overall unreliability is the product of the individual system unreliabilities i.e.

$U_{overall} = U_1 \times U_2 \times U_i \times \dots . U_s$

Common Mode Failure is that failure due to fault which causes more than one element in a system to fail. For example, loss of air supply to a pneumatic flow control loop causes failure of D/P transmitter, controller and valve.

Failure Rate Data of various components are needed for reliability calculations. Following Table gives some such data from international literature.

Average Failure Rates for some mechanical, hydra hydraulic and pneumatic components

Sr. No.	Component	Failure Rate % per 1000 hrs.	Type of Fault
1	Seals or valves, Gaskets, Joints(pipes), Orifices, Diaphragms (metal), Bellows (metal)	0.05	Leakage / blockage
2	Bourdon tubes	0.005	Leakage

		0.02	Creep
3	Joints (mechanical)	0.02	Breakage
4	Nuts, bolts, rods, shafts	0.002	Breakage or loose
5	Pressure vessels	0.3	Rupture or leakage
6	Pipelines Dia upto 3" Dia 3" – 15" Dia > 15"	Failure rate per meter per year Rupture 10^{-6} 10^{-7} -	 Leakage 10^{-5} 10^{-6} 10^{-8}
7	 Pressure vessel Atmosph. Vessel	Failure rate Rupture Rupture 10×5^{-6} 10^{-4}	Per year Leakage $10x5^{-5}$ 10^{-3}
8	Human error Walk through inspection Checklist inspection Non-routine operational error (start-up / maintenance) Non-critical routine task (misread temp/ press data) Critical routine task (tank isolation)		Probability of error / task 50^{-1} 10^{-2} 10^{-1} $3x10^{-3}$ 10^{-3}

Availability characteristics in a process plant are (1) Probability of obtaining nominal output and downtime (2) Probability of obtaining other outputs and downtimes and (3) Probability of infrequent but very long downtimes.

The objective of system availability analysis is to assess system availability and to identify critical aspects and then to effect required improvements.

Data on availability of whole subsystems are useful, otherwise it is necessary to calculate system availability from failure rate and repair time data. Availability of raw materials and services and availability of other plants which receive outputs like by-product, electricity, steam etc. are to be considered.

Availability A(t) is a function of time and may be expressed in terms of uptime u(t) and downtime d(t) as

$$A(t) = \frac{u(t)}{u(t) + d(t)}$$

The unavailability v(t) is

$$V(t) = 1 - A(t) = \frac{d(t)}{u(t) + d(t)}$$

In addition to methods like density function, Markov models, logic flow diagrams and throughput capability method, computer flow sheeting methods can also be used to determine plant availability. Plant availability is affected by storage (main and intermediate), which introduces additional flexibility and may allow units upstream or downstream of a failed unit to continue to operate for a time.

For other principles and mathematical details see Reference No. 27 at the end:

5.2 Application of Reliability Engineering :

Reliability engineering was developed during the second world war to solve the problems of reliability of the missile and vacuum tubes used in electronic equipment by the US Army.

Main fields of application of reliability engineering are electronic equipment [see IS:7354 (6 Parts) and IS:8607 (8 Parts)] and nuclear energy. Methods are developed to assess the hazards of nuclear reactors and to design instrument trip system to shut down safely. Its application to process industries was developed at a later stage.

Reliability of mechanical equipment pose less problem. Reliability application is also concerned with availability, maintenance, failure data, repairs and repair time etc. With the growth of instrumentation and control branch of engineering, applicability of the reliability engineering in process plants has become wide and more important. Complex distributed circuit systems (DCS), trips and alarms, auto control and auto corrections, locks and interlocks and a variety of process control equipment for inputs, outputs, flow, temperature/pressure measurement, recording etc. are increasing, day-by-day, the need of application of reliability engineering.

Work on reliability involves assessment and improvement of the system. The assessment work may show that the system is fully reliable or less reliable and the ways and means to improve the reliability. It is the duty of the reliability engineer to identify the areas where improvement is necessary. Existing level of reliability should be studied for further improvement Failure rates, effects on people exposed if failure occurs and weather conditions are factors to be considered.

Quality control improves reliability. Deficiencies in specification, design or application are causes of unreliability. A good quality equipment, if badly designed, will remain unreliable.

5.3 Concepts of Critical Equipment and Devices :

Reliability analysis of critical equipment and devices like safety valve, auto control valve or device, trip device, flow, temperature or pressure control, trip device, alarm, measurement or recording device, actuators for safe venting, discharge or transfer, pumps, thermocouples, converter and many electronic subsystems, is of more significance and needs careful consideration of accurate data of failure rates, availability, repair time etc. Some concepts of reliability considerations for such critical equipment are mentioned below in brief :

1. Initially three steps arc required (1) Assessment of system reliability itself (2) Identification of critical features interrupting reliability and (3) Methods to improve reliability and selection of a cost effective or safe methods from different alternatives.
2. For above purpose, first those subsystems (components) should be identified that affect the overall system reliability. No much effort is necessary to go into details of a subsystem which does not affect the overall reliability of the system.
3. Sometimes engineering estimates of data may be sufficient but sometimes field data arc also necessary. The matching of the data to the application is more important.

4. For example, connections of three pumps with a storage tank, all in parallel or two in parallel and one as common standby give selective 'reliability. Similarly a temperature measurement system consisting of three identical thermocouple systems in parallel is reliable but expensive. Since the thermocouple failure rate is II times greater than converter and recorder failure rates, a more cost effective redundant system would have three thermocouples in parallel and only one converter and recorder. Alternative way is to place a middle value selector.
5. Use of logic flow diagram (Fault Tree Analysis) is a widely used method. Failure diagram for hazardous occurrences and success diagram for trip system operation or plant availability are utilised.
6. In event space method, a list of all possible events is made and failure and success events are sorted out.
7. In path tracing method the paths in a system are traced which constitute success. These paths are known as tie sets and the system reliability is obtained from the minimum tie sets.
8. The reversed method is to fit cut sets which break all the paths and thus ensure failure. System unreliability is obtained from the minimum cut sets.
9. Bayes' theorem is used to select a key component which makes it possible to decompose the system.
10. Markov models are used to determine repair rates and mean life for complex systems.
11. Monte Carlo simulation methods, are also useful to determine reliability and/or availability of complex systems including-critical equipment.
12. The concepts of consequence analysis i.e. effects on exposed and vulnerable people, property and environment, if any critical equipment or device fails, arc to be considered and depending on their gravity, the reliability of the equipment should be selected.

6 MAJOR ACCIDENT HAZARD (MAH) CONTROL

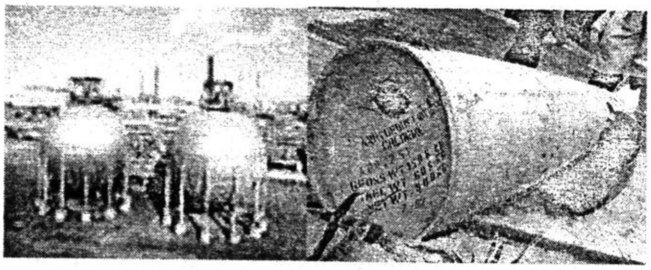
With the growth of chemical industry and use of hazardous chemicals, the world had seen many major accidents during last 50 years but the concept of major accident hazard (MAH) control came in our country after Bhopal accident in 1984 only. Thereafter there is a constant rise in bulk storage, hazardous processes and heavy transportation of dangerous chemicals. This needs to realise and take appropriate safety measures to identify and prevent the major accident causes and to mitigate their consequences.

6.1 Concept of MAH:

Some definitions are as under:

For definitions of 'major accident' and 'major accident hazard' (MAH) see definitions in rule 2 (j) and 2 (ja) of the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989. See part 10.8 of Chapter 28 for further detail.

Major hazard means that hazard which arises because of (1) the hazardous nature of the substance and (2) its storage quantity equals or exceeds the threshold quantity prescribed in MSIHC Rules 1989.



Major hazard is due to isolated storage or industrial activity that has the potential to cause extensive damage to men, materials or environment within or outside the site boundary.

The Statutes - Manufacture, Storage and Import of Hazardous Chemicals Rules 1989, Rule 68J of the Gujarat Factories (Amendment) Rules 1995 and the Chemical Accidents (EPPR) Rules 1996 have defined the term 'major accident'. See Chapter-28 for these laws

Some reported major industrial accidents arc mentioned below:

Examples of Major Accidents

Year	Place	Deaths	Injuries	Chemical involved
1943	Germany	57	439	Butadiene & Butylene (butene), explosion
1944	US	136	77	Methane, fire
1948	Germany	207	3818	Dimethylether, explosion
1954	Germany	32	16	Kerosene, explosion
1966	France	18	90	LPG, fire, BLEVE
1973	US	40	-	LNG, fire
1974	US	7	152	Propane, explosion
1977	Columbia	30	25	Ammonia, toxic release
1978	Mexico	52	-	Methane, fire
1980	Spain	51	60	Propane, explosion
1984	India	2500	25000	Methyle isocynate, toxic release
1985	Mexico	650	2500	LPG, fire, BLEVE
1986	Russia	31	200	Atomic radiation
1993	Thailand	211	-	Toy factory
1993	China	84	-	Plastic toy factory

The Bhopal disaster has remained at the top and opened eyes throughout the world regarding major chemical hazards, their consequences and controls.

All such accidents, differing in the mode of happening and the chemical involved, have some common features as under :

1. They were uncontrolled events caused by fire, explosion or/and toxic release.
2. They resulted in death or/and injury of a large number of people, inside or/and outside the plant, or/and
3. They caused evacuation of people of the 4 surrounding area, or/and
4. They caused heavy damage to plant, property and environment.

The storage, process, use and handling of such flammable, explosive or toxic chemicals pose high potential to cause disasters and are normally referred as major hazards. Their potential is due to their inherent nature (property) of the chemicals, their quantity, type of process, way of handling or sudden failure of some part of the plant including vessel, equipment, fitting, pipe and vehicle.

The main objectives of major hazard control system are:

1. To distinguish between minor and major accident potential and to set priority for identification and inspection of major hazard works first or more frequently.

2. To define hazardous chemical by defining its fire, explosion and toxicity criteria and to define their threshold quantities for storage and use to classify the work as MAH installation.

3. To define and list the hazardous processes to identify the unit as MAH installation.

4. To make, enact and implement the law for MAH chemical works or isolated storage by providing statutory provisions and requirements.

5. To identify the major hazards, developing and utilising the special techniques like hazard and risk assessment, HAZOP, FTA, ETA, consequence analysis, vulnerability analysis, environmental impact assessment etc. as mentioned earlier and carrying out plant safety inspection by various methods mentioned in Part 2 & 4 of this Chapter.

6. To take all possible preventive measures based on identified major hazards to prevent the causes of such hazardous events. Training and education may be incorporated.

7. To foresee the consequences on the workers, public and environment in case if any possible major accident may occur, and to work out an emergency action plan to control and mitigate the effects.

Components of a major hazard control system re:

1. Definition and identification of MAH installation based on types of hazards.
2. Information about the installation e.g. safety report, safety manual etc. Information should be given to workers, public and authorities.
3. Assessment of major hazards, by works management and competent authorities. Cause, effects, consequences and safety measures must be assessed.
4. Control of the causes of major industrial accidents by detecting causes and following sound engineering and management practices e.g. good design, fabrication, installation, operation, maintenance, inspection and use of good safety equipment and instrumentation.

5. Safe operation of major hazard installations by training to workers, following SOPs and investigating accidents and near misses.

6. Emergency planning i.e. on-site and off-site emergency plans and their regular-rehearsals.

7. Siting and land-use planning by ensuring safe separation distances.

8. Inspection of MAH units by the plant management and also by the Govt. authorities at top priority and more frequently.

Causes of major accidents to be studied include component failure, deviations from normal operating conditions, human and organisational errors, outside accidental interference, natural forces, mischief and sabotage.

Safe operation of MAH installation should pay attention on

(1) Design, manufacture and assembly of components,
(2) Process control,

(3) Safety systems (sensors, controllers, pressure relief, emergency shutdown, bunds, water spray, fire detector etc.),
(4) Monitoring of safety-related components and systems,
(5) Inspection, maintenance and repair,
(6) Effects of change,
(7) Training of workers,
(8) Supervision and
(9) Control of contract work.

6.2 Types and Consequences of Major Accident Hazards:

Generally fire, explosion and toxic release are the main types of major hazards and death, injury, evacuation of people, property loss and environmental damage are the main types of their consequences.

6.2.1 Fire, Explosion and Toxic Release:

Fire can cause thermal radiation and skin burns. The severity (degree and percentage) of burns depends on heat intensity, exposure time and type of clothing.

Heat radiation effect $\alpha = \dfrac{1}{\text{distance}^2}$

Generally skin withstands a heat energy of 10 kW/m^2 for 5 seconds and 30 kW/ 2 for only 0.4 seconds before pain is felt.

Frequency of fires in industry is more than explosions and toxic releases but its lethal effects are comparatively less. However if the ignition of escaping flammable vapour is delayed an unconfined vapour cloud may form and it may explode if ignited.

Types of fire may be a jet fire, pool fire, flash fire and BLEVE i.e. boiling liquid evaporating vapour explosion. A jet fire occurs from an ignited gas pipe leak, a pool fire from drained material in a dyke, flash fire occurs if the gas reaches a source of ignition and rapidly burns back to the source of release and BLEVE occurs when flammable vapour leaking from any vessel or pipe expands and disperses in air as a cloud and when this cloud is ignited. Then a fire ball occurs causing enormous heat radiation. A BLEVE from a 50 tonne propane tank can cause third-degree burns at @200 mts and blisters at @400 mts.

Explosion is a shockwave that can damage where it hurts. Primary or direct effect is due to the shockwave of the explosion itself. Those in the direct vicinity may die due to effects of over-pressure. People can also be thrown away, blown over or knocked down and buried under collapsed materials. Secondary or indirect effect is the effect of shock-wave generated by the primary effect. The history of explosions show that the indirect effects of collapsing buildings, flying or broken glasses and debris cause far more deaths and injuries.

The effects of shock-wave depend on the type of material, its quantity and the degree of confinement of the vapour cloud. A pressure of 5 to 10 kPa can cause direct injury. Death may occur at a higher pressure but demolition of building or breaking of windows occur at 3 to 10 kPa. The pressure decreases rapidly with distance. As an example, the explosion of a 50 tonnes propane tank can cause a pressure of 14 kPa at 250 mt and 5 kPa at 500 mt.

Types of explosion are deflagration, detonation, confined and unconfined vapour cloud explosion and gas and dust explosion.

When burning velocity or flame speed is slow (e.g. I to 10 m/sec), deflagration takes place in a confined space. It generates low pressure (e.g. 70-80 kPa).

When flame speed is very high (e.g. 2000-3000 m/ ' sec), it causes detonation and generates high pressure like 200 kPa. Some degree of vapour confinement is necessary.

Explosion in a confined place like vessel, pipework, drain or building is called confined explosion and that occurring in the open air is called unconfined explosion. Confined explosion causes higher pressure and may reach upto hundreds of kPa.

Explosion of a vapour cloud after heavy leakage of a flammable gas is called gas explosion. Large vapour cloud can cause unconfined vapour cloud explosion (UVCE), boiling liquid expanding vapour explosion (BLEVE) or fire ball.

Explosion of a solid material in the form of dust, powder or small particles mixed with air is called dust explosion. Grain, milk powder, flour and coal dust are flammable dusts. Effect of dust explosion is mostly confined to the workplace.

See Chapter-13 for more details and control measures for Fire and Explosion.

Toxic releases are caused due to leakage and dispersion of toxic chemicals (gas or vapour) in air. As the workers are working nearby they can be affected first. Therefore workplace monitoring, air/gas sampling, environmental monitoring etc. as mentioned in Part 1.6 and 1.7 of Chapter-24 are all important.

Consequences of toxic release are influenced by wind speed, weather condition, leak rate or mass released, toxicity (LD/LC) and concentration (ppm) at a particular place, and also by age, sex, genetic background, ethmic grouping, nutrition, vulnerability (old or tender age, sickness, disease), exposure to other substances with synergistic effects, pattern of work and time of exposure.

Chlorine, ammonia and other chemicals like methyl isocynate have caused disasters. Study o toxicity and consequence analysis of such chemical and advance emergency planning are most essential For example, instantaneous release of 10 tonnes chlorine may produce 140 ppm at a 2 km downwind distance and 15 ppm at a 5 km distance in D5 weather Chlorine can be lethal at 1000 ppm or at 100-150 ppm for 5-10 minutes. Its effect is dangerous even at 10-2C ppm for 30 minutes. Such data should be kept ready by all major hazard works in respect of their highly toxic chemicals with effect (distance and ppm) counter; of surrounding area.

6.2.2 Types and Effects of Gas Dispersion:

(1) Types of Toxic Spills : Three types : liquids, gases stored as liquids (like Cl_2, NH_3) and gases (N_2, O_2)

No buoyant plume created, unless there is a fire

Liquid Spills : Material which is normally a liquid at atmospheric pressure and temperature causes a pool to form. viz., benzene, acrylonitrile and vinyl chloride

Rate of evaporation from the pool depends on:

1. Vapour pressure of the liquid.
2. Area of the pool.
3. Heat of evaporation.
4. Air temperature.
5. Ground temperature:
6. Heat transfer of convection & radiation etc.

The viscosity of the liquid determines the rate of growth of the pool, i.e. its area.

Generally the initial rate of emission will be greater per unit area than the equilibrium rate. The pool is cooled because of evaporation.

Liquid Gas Spills : Material stored in pressured and/or refrigerated containers, -viz. Cl_2, NH_3, LPG.

If the release rate is slow enough the material will enter the atmosphere as a gas. But in a sudden release such as a tank rupture, the dispersion process can be described in 4 phases.

1. Turbulence called 'flash off caused by rapid escape of the liquid or gas. For a 20-ton NH_3, tank rupture, tests suggest @20% vapour & 80% liquid aerosol coming out as a cloud.
2. The cloud (liquid cylinder or column) starts to slump like a water column starts to spread out. During slumping, air is entrained slowly. This second stage lasts 30 to 40 seconds for a 20-T NH_3, spill.
3. The gas cloud now enters the ground hugging phase. Most of the air entrainment takes place through the top surface. Depending on ambient temp., gases in the cloud will reach ambient air density in 3 to 5 minutes after slumping starts from a 20-T NH_3, spill.
4. The natural process of atmospheric turbulence takes over, and the cloud diffuses while travelling along with the wind, like any other material in the atmosphere.

Gas Spills : Such spill results in the formation of air-gas mixture at a temp. some what below ambient temp.

(2) Meaning of Dispersion and Effects:

Dispersion and diffusion means spreading and dilution of gas in air. When smokes come out from a chimney, vaporisation takes place from boiling or evaporating liquid, any material leaks or spills due to leakage or handling and discharges gas or vapour in atmosphere, safety valve or vent opens and liberates gases, any accidental failure of any vessel or equipment occurs giving sudden rise of vapours or gases or due to any fire or explosion when gases come out, dispersion phenomenon takes place. Because of discharge pressure, lighter vapour density, buoyancy, kinetic energy, temperature etc. the escaping material travels in air and because of turbulence in air and wind velocity the mixing (air-entrainment), diffusion and spreading in wind direction take place. Weather conditions and topographical factors also affect. Dispersion may be of a flammable gas-air mixture or non-flammable (inert, toxic or corrosive) gas-air mixture. It may be a continuous emission or instantaneous puff or plume release.

The dispersion is of more concern when it is of very toxic gas or highly flammable vapour, because it can give direct rise to toxic effect, fire or explosion.

Toxic release in bulk quantity and for a long duration (e.g. Bhopal incident) affects public at large. To assess the consequence, fatalities, injuries and property damage and for the purpose of evacuation to save life, scientific calculations become necessary which include probit equation and analysis and -a variety of gas dispersion modelling. The computer models can give quick results.

In case of toxic dispersion, normally three zones are considered. The inner most or zone-1 contains the highest concentrations of leaking gas wherein maximum fatality/injury can be predicted. No entry or no rescue operation may be possible there. Then in intermediate or zone-2, evacuation becomes most necessary and must be carried out at the earliest possible otherwise great fatalities or/and injuries may result. This is the target area of emergency planning and rescue activities. But in doing so, use of necessary personal protective equipment and vehicles is to be done very carefully. The outermost or zone-3 is a safe zone but it can be affected also if dispersion aggravates or lasts for a longer time. Therefore alert and warning action is required in this zone. People must be advised to go away by their own arrangement and should be helped if necessary.

A flammable gas in explosive range with air can cause fire or explosion and may be consumed by combustion. But a large vapour cloud is capable of producing an unconfined vapour cloud explosion. Boiling liquid expanding vapour explosion (BLEVE) and/or fireball are also possible.

A dispersing gas gets diluted in air during dispersion, diffusion and travelling and its 'density becomes close to air density. Therefore the majority of dispersions are known as 'air-density or neutral density dispersion'. Only some dense gas dispersion needs special calculations and treatment.

A gas released from any point may be ignited if flammable and may cause, BLEVE, flare or pool fire and cause heat radiation damage. Fire may generate toxic products and adds toxic effects too. If immediate ignition is not possible, the gas may vaporise, disperse and may cause delayed ignition which by pressure wave may cause flash fire or explosion and ultimate damage. If the released gas is not flammable but toxic it causes toxic effects and if it is inert like nitrogen, causes oxygen deficiency in a confined space. It the gas is in no way injurious, no adverse effect is possible.

Types of releasing gas may be of the following

1. Liquefied pressurised gas (e.g. LPG).
2. Flammable gas (e.g. fuel gas, H_2).
3. Toxic gas (e.g. Cl_2 NM_3, CO).
4. Low boiling liquid (e.g. petrol/benzene).
5. Liquid with toxic combustion products.

Their hazardous effects may be of the following types.

1. Heat radiation from a jet, pool fire, a flash fire or BLEVE.
2. Explosion overpressure.
3. Toxic effects from toxic materials or toxic combustion products.

The following effects consequential to the accidental release of hazardous materials are of much interest:

1. Atmospheric dispersion as a function of source strength, gas density, weather conditions and topographical situation of the surrounding area.

2. Intensity of heat radiation (in kW/m^2) due to a fire or a BLEVE as a function of the distance of me source.
3. Energy of vapour cloud explosions (in N/m^2) a.' a function of the distance of the exploding cloud
4. Concentration of the evaporated material which may be explosive or toxic.
5. Concentration of the toxic products-of combustion produced by a fire and
6. Duration that these respective effects may prevail.

Some damaging effects due to heat radiation, blast overpressure or toxic concentration are summarised below:

(A) Radiation Effects:

Exposure Duration	Radiation energy required for 1% lethality	
	Without protection	With protection (e.g. clothing)
	(kW/m^2)	
10 Sec	16.7	21.2
30 Sec	7.3	9.3

(B) Blast wave Effects due to Overpressures :

Type of damage	Peak overpressure
Total destruction	0.830 E + 5 Pa
Heavy damage	0.350 E + 5 Pa
Moderate damage	0.170 E + 5 Pa
Minor damage	0.035 E + 5 Pa

Approximately 0.1 bar peak over pressure may cause 1% fatality or serious damage to 10% of the housing/structures.

(C) Toxic Effects (fatalities) :

Chemical	LC30 in mg/m3 (lethal concentration at 30 min exposure)	
	1% Fatality	50% Fatality
NH_3	1871	5999
CO	787	7949
Cl_2	364	1005
EO	432	4443
HCl	391	3950

Dispersion can be studied in four types of areas (1) Leaks and spillage (2) Dispersion from vents and jets (3) Dispersion of heavy gases and (4) Dispersion by fluid curtain. Simultaneous study of meteorological and topographical conditions becomes a part of the subject of dispersion and modelling.

6.2.3 Probit Analysis

Probit Analysis is a method (calculation) tc assess probability of injury or damage due to serious or lethal dispersion. It is a mathematical expression in the form of a probit function as under :

$$V = K_1 + K_2 \text{ In } C \qquad (I_n = \log_e)$$

where V is a measure of the vulnerable resource (human or property) which gets injury or damage, and variable C is a measure of the intensity of the causative factor which harms the resource.

The logarithmic term (I_nC) i.e. log C in above equation arises because in any population, some people can tolerate high intensity of harmful causative factor than others. The distribution is slanting (oblique).

The constants K_1 and K_2 can be calculated from the relationship between the intensity of causative factor and the degree of harmful response. In case of fire, K_1 and K_2 depend upon effective time duration(s), radiation intensity (W/m^2), duration of pool burning(s) and radiation intensity from pool burning (W/m^2). In case of explosion, they depend on peak over-pressure (N/m^2) and impulse (Ns/m^2) and in case of toxic release, they depend on concentration (ppm) and time interval (min).

In case of fire, burn deaths may take place due to flash fire or pool burning. In case of explosion, deaths or injuries may take place due to impact, card rum rupture, flying fragments, structured damage, glass breakage and lung haemorrhage. In case of toxic release, deaths or injuries may take place due to toxicity and concentration of the gas.

In case of fire, deaths or injuries may happen due to thermal radiation. This effect is time-dependent and is given by following probit equation :

$$P = K_1 + K_2 \ In \ C^n t = K_1 + K_2 \log, C^n t$$

where P is the probit i.e. a measure of probability of people that may be affected, K_1 and K_2 constants, C a causative factor (here radiation intensity in kW/m^2), n = 4/3 and t = time in seconds.

The values for K_1 and K_2 are mostly derived from experiments with animals. However, human toxicity factors have been derived from past accidents. Inhalation experiments with rats seem to be best applicable to predict damage to people from acute intoxication.

In above probit equation following probit constants are relevant for the following chemicals :

Chemical	Probit Constants		
	K1	K2	N
NH_3	-15.8	1	2.0
CO	-7.4	1	1.0
Cl_2	-14.3	1	2.3
EO	-6.8	1	1.0
HCl	-6.7	1	1.0

Examples:

(1) Let us consider C = 21.2 kW/m^2 radiation energy for I % lethality with exposure time 10 seconds, then for Ethylene oxide (E.O),

$$\begin{aligned} P &= K_1+K_2 \ In \ C^n t \\ &= -6.8+1 \ In \ (21.2^1 \times 10) \\ &= -6.8+1 \ In \ (21.2 \times 10) \\ &= -6.8+In \ 212 \end{aligned}$$

	=	- 6.8 + 5.35
	=	-1.45

(2) Let us consider C = 1871 mg/m^3 concentration for ammonia at its LC_{30} then for 20 seconds exposure,

P	=	$K_1+K_2 \text{ In } C^n t$
	=	- 15.8 + 1 In (1871^2 x 20)
	=	- 15.8 + In (3500641 x 20)
	=	- 15.8 + In 70012820
	=	- 15.8 + 18.06
	=	+ 2.26

(3) Let us consider C = 25 mg/m^3 concentration for chlorine, then for 5 minutes (5 x 60 = 300 seconds) exposure,

P	=	$K_1+K_2 \text{ In } C^n t$
	=	- 14.3 + 1 In ($25^{2.3}$ x 300)
	=	- 14.3 + In (1641.57 x 300)
	=	- 14.3 + In 492473.96
	=	- 14.3 + 13.10 = -1.2

The profit P is a random variable with a mean 5 mid variance 1. The probability (range 0 - 10) is generally replaced in probit work by a percentage (range 0 - 100) from the following table :

Probit	% (approx)
2.5	0
2.67	1
3	3
3.5	8
4	15
4.5	30
5	50
5.5	70
6	85
7	98
7.5	100

Thus probit P = 2.67 represents 1% of the exposed 'population, P = 5 represents 50% of the exposed population, P = 5.5 represents 70%, P = 7 represents 98% and P = 7.5 represents 100% of the exposed population or percentage damage or degree of injury that can result from the exposure.

In previous example (2) of ammonia release, P = 2.26 indicates that approximately 0.9% of the population may be affected.

A common rough estimate for the hazard range for large pool fires is about 2 pool diameters, and for large drifting vapour clouds 1.5 cloud diameters.

Thus a probit equation generally gives the relation between the causative factor and the probability of death.

However it should be borne in mind that probit equations are just approximation 'in an impact model of hazard assessment and there may be a vast difference in actual result.

See also Part 4.12 for use of Probit Equation.

6.3 Criteria (Identification) for the Plant to be under MAH unit :

Schedules 1, 2 and 3 of the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 (and also u/r 68J of the Gujarat Factories Rules) prescribe criteria for toxic, flammable and explosive chemicals, list out the hazardous chemicals and give their threshold quantity for application of certain rules. These storage quantities and processes listed in Schedule-4 are, now, legal criteria to identify the plant to be under MAH unit. For details the Schedules should be referred.

Chemical	Quantity (t)	Chemical	Quantity (t)
HCl gas	25	Chlorine	10
NO_x SO_3	50 15	Formaldehyde	5
Acetylene	5	HCN, HF, H_2S	5
Acrylonitrile	20	SO_2	2
Ammonia	50	EO	5
Bromine	40	Hydrogen	2
CS_2	20	Phenol	10

Thus the plants keeping quantities equal to or more than the threshold quantities mentioned in the Schedule-3 (above table is a part thereof) or the isolated storage (other than a factory) storing quantities equal to or more than the threshold quantity mentioned in the Schedule-2 (e.g. Ammonia 60t. Flammable gases 501, Highly flammable liquids 10000t, Bromine 50t) are to be identified as major hazard installations (factories or isolated storage).

As the Oleum is not named in Sch. 2 or 3, the quantity of S0,, (15t) is to be considered for oleum.

For the purpose of determining the threshold quantity of a hazardous chemical in a factory or isolated storage, the aggregate of all installations within a distance of 500 mt of each other and belonging to the same factory/isolated storage (or the same occupier) shall be considered as mentioned in Sch. 2 & 3.

Based on above discussion, the MAH units are mostly those associated with

1. Storage/processes of Cl, NH,, & LPG.
2. Other chemical/petrochemical plants and refineries.
3. Pesticide factories.
4. Explosive factories and
5. Large fertiliser plants.

6.4 Role of the Management

Under the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 the general responsibilities of management of any MAH unit are to

1. Provide information to the authorities, of criteria, quantities and processes of hazardous substances to identify the unit as an MAH unit. See Rule 4 & 7, and Sch. 7 &: 9 for notification of site and MSDS.
2. Carry out Safety Audit and Risk Assessment and collection, development and dissemination of information as mentioned-in Rule 17 and Sch. 8 to 12. Submit Safety Report and Safety Audit Report.
3. Report to the authorities the results of the hazard/ risk assessment in the prescribed formats e.g. Safety Report in Sch. 8, MSDS in Sch. 9, Information of imported chemicals in Sch. 10, Onsite Emergency Plan in Sch. II and information required by the authority to prepare Off-site Emergency Plan in Sch. 12. This plan is to be rehearsed once in a year.
4. Set up an emergency plan i.e. on-site and off-site emergency plan based on the guidelines from Factory Inspectorate. See Sch. II & 12.

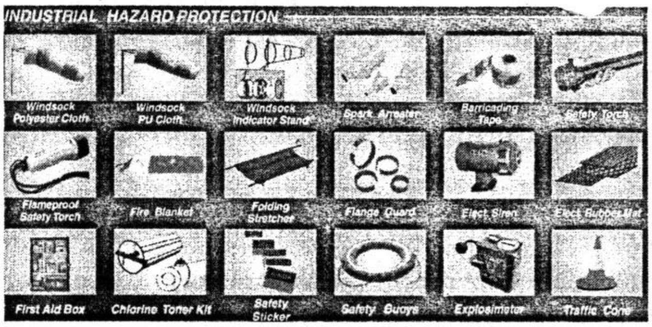


Fig. 19.1 Major Hazard Protection Equipment & Stickers

5. Take all necessary safety measures to prevent major accidents and to limit their consequences to persons and environment, provide to the workers with information, training and equipment including antidotes necessary to ensure their safety as mentioned in Rule 4. This is the main responsibility to operate and maintain the plant safety and to mitigate consequences .of the accident. See Fig. 19.1 for Major Hazard Protection Equipment & Stickers. They should be used and displayed.
6. Update the information following changes in the threshold quantity, other hazards and safety report as mentioned in Rule 8 and 11.
7. Give information to the public liable to be affected by a major accident as mentioned in Rule 15.
8. Notify within 48 hours, to the concerned authority mentioned in Sch. 5, a report of major accident occurred on site in the Sch. 6. See Rule 5.
9. Inform the concerned authority (mentioned in Sch. 5), before 30 days, the particulars mentioned in Rule 18, regarding import of hazardous chemicals. The records of imported hazardous chemicals shall be maintained in Sch. 10

For various methods of hazard/risk assessment see Part 4.3 of this chapter.

6.5 Role of the Authorities :

In controlling major industrial hazards and accidents, the Government authorities have an important role to play as Under

1. To enact, implement and amend the law on major hazard control.
2. To require statutory information from industries to identify them as MAH installations (sites & isolated storage), in the form of Safety Report, onsite emergency plan and other relevant information.

3. To compile the data of MAH units, nation-wide, statewise and districtwise with the lists of MAH factories, isolated storages, hazardous chemicals involved in such units, their quantities, types and consequences of hazards and areawise contingency (emergency action) plans.
4. To publish and circulate useful information for the MAH management, their workers and the general public. This should include the role of different agencies and the public and information on medical help and antidotes.
5. To set up the Crisis Alert System as provided by rule 4 of the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules 1996. See Part 10.10 of Chapter-28.
6. To establish and maintain uptodate an inventory of MAH units based on the Safety Reports received and location of the units in relation to populated areas.
7. To inspect the MAH units based on safety reports and on-site emergency plans received to check the correctness and effectiveness of the safety arrangements provided. To give direction for further action if necessary.
8. To draw up an off-site emergency plan (by local authorities) after consultation with the MAH units and agencies like fire brigade, police, hospitals and ambulance, transport, telephone etc. Budget and arrangements to train participants and public and carry out rehearsals should be made.
9. To make and implement siting policy to separate MAH units from other units and population.
10. To acquire for self, expertise by establishing a group of experts, to prepare checklists to evaluate plant safety measures and to develop inspection systems and programmes for the use of Factory Inspectorates.

6.6 Role of the Workers:

The workers of the MAH units have to play an important role as under :

1. They should understand the concept of major hazard control and its importance to operate the plant safely.
2. They should give full co-operation in undergoing training and implement it to run and maintain the plant with safety and responsibility so as to avoid any hazard or accident to self and others.
3. They should watch their workplaces for safety, use necessary equipment and follow safe working procedures for their health and safety.
4. They should know and play their role in the onsite emergency plan of their company.
5. They should make proper use of safeguards and safety devices meant for them and co-workers.
6. They should not displace, alter, remove or interfere with safety guards, devices and appliances.
7. They should not temper with process controls, valves, piping, pumps, mechanical, electrical and other machines and equipment so as to cause any deviation or hazard.
8. They should not do any unauthorised act.
9. They should report immediately imminent dangers, defects or any unsafe condition to their supervisors, safety committee members or the concerned safety officers.
10. The trade unions can also contribute by educating and training their members on above matters. They should give active co-operation to the management in implementing major hazard control system.
11. The workers or their unions should prepare and circulate training and information materials addressed to workers to promote safety awareness and their duties toward health & safety.

6.7 Role of the Public:

The public has to play their role as under :

1. They should know their role at the time of off-site emergency affecting them. They should attend meeting for this purpose with the authorities and the factory management and to clarify their doubts and duties.
2. At the time of off-site emergency they should follow the instructions for them regarding their staying in houses or be prepared for evacuation. They should not make panic or frighten others by misguiding or spreading false information.
3. The injured people should take immediate medical help or antidotes suggested by the doctors.
4. The public should give full co-operation in emergency activities entrusted to them by the authorities e.g. traffic control, helping sick and handicapped persons etc.
5. They should not cause obstructions, hindrances or difficulties at the time of emergencies. They should give correct information to the authorities.

6.8 Safety Report, Safety Audit Report and Risk Assessment Report.

6.8.1 Safety Report:

Statutory information required in a safety report is given in Sch. 8, Rule 10(1) of the MSIHC Rules, 1989

Before 90 days of any modification (having material effect), an updated Safety Report shall be submitted to the authority.

6.8.2 Safety Audit Report:

Safety audit with the help of an expert not associated with such industrial activities is to be submitted every year within 30 days after the completion of such audit.

Like financial audit, 'Safety Audit' has also been popularized and has come into practice since last ten years. After statutory requirements (GFR 1995 & MSIHC Rules 2000), audit frequency has been increased. Looking to this need, BIS also published an Indian Standard - IS:14489 in 1998 as standard guideline for practice on occupational safety and health audit. This IS does not include rating (points) system like British Standard. Therefore, it gives qualitative analysis and not the quantitative.

1. Need of Safety Audit:

Safety audit is mainly required for two reasons:

(A) **Safety Requirement:** It is utmost necessary for the purpose of maintaining safety (accident free atmosphere) in industry that all systems of work should be thoroughly checked from safety point of view at regular interval and deficiencies identified should be removed by due compliance of safety recommendations. -A pro-determined checklist is useful for a fixed class of industry (e.g. chemical industry) but, however, audit points are variable and should be best suitable to the type of industry to be audited.

(B) **Legal Requirement:** Rule 12-C & 68-0 of the Gujarat Factories Rules 1963 and Rule 10 & 12 of the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 need submission of safety audit reports to the concerned authorities within prescribed time.

2. Audit Procedure:

Lead auditor along with his team may adopt following procedure:

1. Constitution of Audit team (at least two members).
2. Constitution of Auditee representatives.
3. Recording identification and brief history of the auditee industry.
4. Deciding audit goals, objectives and scope.
5. Drawing audit plan with time schedule.
6. Holding opening meeting with the auditee.
7. Study of process and applicability of safely laws and standards.
8. Taking plant round and noting observations.
9. Examining records and documents.
10. Filling checklists of audit points (e.g. filling of Annexure A, B & C of IS-.14489). Element wise (Annex. A) files will be useful.
11. Holding of closing meeting and discussing findings.
12. Preparation and submission of Audit Report (with Executive summary in the beginning).
13. Report distribution for compliance.
14. Compliance audit if required by the audittee or client.
15. Visit for compliance audit and its report.

3. Audit Frequency:

Normally an external or third party safety audit should be conducted once in two years and an internal audit may be organized once in every year.

4. Audit Goals:

Following goals can be decided while starting the audit:

1. Assessment of Auditee's OS&H system against existing standards and identification of areas for improvement.
2. Determination of conformity of the implemented OS&H system with specified requirements and identification of areas for improvement.
3. Checking of statutory requirements.

5. Audit Objectives:

Following objectives can be decided for the audit:

1. To carry out a systematic, critical appraisal of all potential hazards involving personnel, plant, services, methods etc.
2. To ensure that company's OS&H system and safety policies, objectives etc. satisfy the legal requirements.

6. Audit Scope:

The scope and depth of the audit should be decided as per auditee's or client's requirements. This should include:

1. Which plants or areas to be audited.
2. Which OS&H system elements to be audited.
3. With what legal and other safety standards, rules or documents, the auditee's OS&H systems should be compared. Benchmarking if any, should be considered.

4. List of resources and evidences including workers and experts that will be available for audit.
5. Within what time frame audit should be completed and with what other terms and conditions. A written agreement, if necessary, should be prepared and signed.

7. Audit Plan:

Audit plan should be finalized after consultation with auditee and should be informed to auditors and auditee in the opening meeting. This plan should include:

1. Audit goals, objectives and scope as stated earlier.
2. Names of audit team members and management's representatives.
3. List of documents to be checked.
4. List of legal and other standards to be followed during audit.
5. Auditee's OS&H policy and its other intentions.
6. Time schedule of audit visits of each plant or location.
7. Schedule of meetings to be held with auditee for the audit purpose.
8. Expected date of issue of the audit report.
9. Procedure or methodology of compliance of the report, and
10. Whether compliance audit will be required by the auditee and if yes, it's probable time schedule, and method of communication.

8. Checking of Records & Registers:

Statutory forms, records and registers under the Factories Act & Rules and other safety laws should be checked for relevant information and statutory compliance. This may include (for Gujarat):

1. Form No. 1 A (GFR) i.e. structural stability certificate.
2. Form No. 9, 10, II (GFR) for hoists, lifts, lifting machines and pressure vessels.
3. Reports of Competent Persons regarding examination of dangerous machines, safety devices, dangerous operations etc.
4. Form No. 29 (GFR) i.e. Accidents Register.
5. Form No. 20, 32 & 33 (GFR) i.e. Health records for workers.
6. Form No. 37 (GFR) i.e. work place monitoring record.
7. Industrial Hygienist's report regarding measured values of gas, vapour, noise, WBGT (Heat stress parameters), ventilation system etc.
8. Statutory cautionary notices, safety policy and minutes of safety committee meetings.
9. Certificate of safety, testing of pressure vessels and safety valves etc. under SMPV (U) Rules 1981 and Petroleum Act & Rules, if applicable.
10. Forms under Gas Cylinder Rules if applicable.
11. Testing certificates of effluents, air pollutants, solid wastes, ambient air quality etc. under GPCB norms.
12. Licenses under applicable Acts and Rules and their validity.
13. Public liability insurance policy, if required.
14. Records of storage quantities of hazardous chemicals for verification of threshold quantities and identification as MAH installation.
15. Records and Registers (29) as suggested by Annexure - B of IS:14489.
16. Other relevant records and registers as considered necessary by the auditors.

9. Checking Applicability of Safety Laws:

From above records, registers, licenses etc. and physical verification of storage quantities, number of gas cylinders etc., act-wise applicability and validity of licenses etc. should be checked, discussed and narrated in audit report.

10. Points of Plant-visits:

All safety points (audit points) seen during plant visits should be recorded plant-wise or location-wise so that plant-wise implementation will become easy. This should be separately reported in the audit report.

Such points are to be seen as requirement of law and other standards. Their mention will include reference of relevant section, rule, standard (attributes) etc.

11. Audit Observations and Recommendations:

Safety audit questionnaire sheet should be prepared in the following form:

Sr. No.	Items to be observed	Observation seen/ found (Non conformities)	Recommendations i.e. safety suggestions.
1	2	3	4

Observations should be clear and specific. Recommendations should also be clear, specific, easy to understand, brief and with reference of safety standard or reason as per auditor's opinion.

Annexure - C of IS:14489 is a good guideline for safety audit which can be used for a chemical industry also. It should be utilized as a whole or with necessary modification deem fit by the auditors. Points may be decreased or increased depending on the size, status, contents, materials, processes, procedures and systems of works and experience of the auditors.

As Annexure - C includes many items of safety •inspection and audit including safety policy, organization, training, general working conditions, hazard identification and control, technical aspect, work permit system, PPE, fire protection, emergency preparedness, hazard area classification, static electricity, vessels and equipments, storage safety, communication system, transport, pipelines etc., they are not separately discussed in this article. There is no end to such items. Only experience can specify and classify them. Therefore, audit by duly qualified and experienced auditors is more useful.

12. Closing Meeting:

After recommendations are ready, prior to preparing the audit report, auditors should hold a closing meeting with auditee's senior managers to explain them the result of the audit. Audit observations and recommendations should be explained to them. Power point presentation is more effective. Querries of the audience should be replied forthwith. Reasons (legal requirements, standards etc.) of recommendations should be properly explained. It should also be clarified that the purpose of this effort (audit) is not to criticize but to try to find out the methods of further improvement.

13. Report Preparation & Submission:

Audit report should be well documented by the auditors, audit certificate should be signed (with date) by the lead auditor and enclosed with the audit report and it should be sent to the auditee or client as soon as possible. If it cannot be sent within agreed time limit, reasons of delay should be communicated. The auditee should send acknowledgement of receipt of audit report to the auditors and client and final report of compliance when it is over.

14. Report Distribution and Compliance:

Auditee will decide internal distribution (relevant copies) of audit report to the concerned departments or managers with its instructions of compliance within specified time limits assigned to each of them. The auditee will collect the reports of compliance, will verify and arrange in chronological order against each point of recommendation.

15. Report Retention:

Auditee should retain the audit report alongwith its compliance report and should show them to the authorities on demand. Such retained audit reports will show the history of safety improvement of the auditee. Minimum time of retention is till full compliance of the audit report. Cost benefit ratio can also be determined based on this.

If compliance or follow-up audit is required by the same auditors, auditee or client should inform them accordingly.

6.8.3 Risk Assessment Report:

As explained in part 4.3 risk assessment should be carried out by using risk ranking table (matrix) and computer models for damage distances due to toxic gas release or fire or explosion phenomena. First hazards of main industrial activities and sub activities are identified. Then ranking points are assigned to them. Quantitative assessment is derived fgr probability and severity part of the risk. Than using the formula risk = probability x severity, risk levels are calculated and tabulated.

A format of risk assessment report should contain following items:

Executive Summary
1. Legal Requirement of Risk Assessment
2. Words and Concepts Defined.
3. Hazards Identification
   3.1 Identification of the Factory
   3.2 Brief History of the Factory
   3.3 List of Products
   3.4 List of Raw Materials.
   3.5 Process in brief
4. Hazards Analysis
   Listing of hazards activity wise and their classification
5. Hazards & Risk Assessment
   5.1 Risks as per Work Environment Report (Form No. 37, GFR).
   5.2 Risks as per Health Records of the Workers (Rule 68 R&T, GFR).
   5.3 Risks due to Toxic Chemicals (as per Gas Dispersion Calculations)
   5.4 Risks due to Flammable Materials
   5.5 Assessment of Residual Risks-material wise or activity wise and using appropritate metrix with formula
      Risk = Probability x Severity.

Tables of ranking points

6. Risk Control
   - 6.1 Control Measures Provided
     - 6.1.1. Risk Reduction Measures
     - 6.1.2. Risk Prevention Measures
     - 6.1.3. Information Management
   - 6.2 Control Measures Suggested.

7. Risk Management
   - 7.1 Functions of SHE & Fire Departments to identify, assess, address, control and review the risks
     - 7.1.1 Functions of the SHE Department
     - 7.1.2 Fire Fighting Facilities.
   - 7.2 Risk Financing (Transfer by Insurance)
     - 7.2.1. Insurance Policies for Workmen's Compensation
     - 7.2.2. Insurance Policies for Property Protection.
     - 7.2.3. Public Liability Insurance.
   - 7.3 Risk Administration
     - 7.3.1. Long-term Programme
     - 7.3.2. Day-to-Day Operations

7 ON-SITE AND OFF-SITE EMERGENCY PLANS

7.1 Need & Types of Emergency Plans

Minor accidents do not cause much damage. But major accidents due to emergency or disaster cause extensive damage to person, property and environment. Many accidents like Bhopal tragedy have occurred at many places in the world causing heavy loss of life and property. Some cases are discussed in Chapter 30. Emergency situation arises all of a sudden and contains high potential to cause havoc. Therefore such situations (chances) and risks should be thought in advance and it should be planned beforehand to tackle them immediately and to control them within the shortest possible time. Reasons of emergency planning are as follows:

Reasons of Emergency Planning :

1. Experience of years have shown that accident, dangerous occurrence, emergency or disaster occurs at any time and we lose life, property, production etc. if not fully prepared to control over and minimise it. Therefore it is most advisable to foresee such situation and to plan for total loss prevention and control.
2. There is no alternative to emergency planning. Only the best planning, periodical drill or rehearsal, co-ordinated and sincere efforts by all authorities at all times and speedy follow up as per planning will help to achieve the goal.
3. Planning reduces the thinking time for necessary steps at the time of accident .
4. It is easy to set in motion all machinery already planned and trained in advance to meet the situation.
5. Prevention is better than cure. Planning intends first prevention and if it fails, subsequent control to cure the situation. Emergency needs such planning. .
6. Planning helps to contain the incident and to minimise the loss to the national wealth including human lives, resources, business and administration.

7. It is our moral, social and legal obligation to serve the society for safety, health and welfare. Emergency preparedness or planning is the best step in this direction.
8. Many companies, organisations and nations have succeeded in above goal by planning and follow up only. This suggests the need for planning.

Types of Emergency:

See Part 3 of Chapter-2 for definitions.

There are three basic types of emergencies : (1) Operating (2) Fire and .(3) Disaster.

1. Operating Emergency : It is an emergency, that can be locally handled by unit personnel alone without help e.g. small fire, air failure, power failure, cooling water failure, steam failure, gas leaks etc'. .
2. Fire Emergency : It is a fire which is beyond the control of operating staff or the unit. It requires the assistance of the other fire fighting force.
3. Disaster , A disaster is a catastrophic situation in which the day-to-day patterns of life are, in many instances, suddenly disrupted and people are plunged into helplessness and suffering and as a result need protection, clothing,, shelter, medical and social care and other, necessities of life, such as -

    (1) Disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm, surges," cyclones, tropical storms, floods, landslides, forest fires and massive insect infestation. Also in this group, violent draught which will cause a creeping disaster leading to famine, disease and death must be included. ..-
    (2) Second group includes disastrous events occasioned by man, or by man's impact upon the environment, such as armed conflict, industrial accidents, factory fires, explosions and escape of toxic gases or chemical substances, river, water, "land and air pollution, mining or other structural collapses; air, sea, rail and road transport accidents, aircraft crashes, collisions of vehicles carrying inflammable liquids, oil spills at sea, and dam failures.

Advance emergency planning and proper training of every employee in the 'emergency function is very essential to make emergency control measures more effective. It is not possible to completely eliminate emergency situations, but it is definitely possible to control them. An emergency, if uncontrolled may cause a disaster which in turn may create a catastrophe.

There are two types of emergency control plans (1) On site emergency plan and (2) Off site emergency or disaster plan. The first is to be prepared by an industrial unit under the guidance of the government and local authority and the second one is to be prepared by the local authority or the government itself with the help of the government machinery and resources including the concerned industrial units also.

They arc explained below as a guide line. Necessary alteration, addition etc. must be made according to tile specific types of hazards, situations and control measures required.

7.2 Statutory Provisions :

Section 41B(4) of the Factories Act, 1948 requires an on site emergency plan and detailed disaster control measures for the safety of the factory workers and the general public living in the vicinity of the factory. The occupier is required to inform the workers and the public about the safety measures to be taken in the event of an accident.

Rule 13, 14 and Schedule II & 12 of the Manufacture; Storage and Import of Hazardous Chemicals Rules, 1989 and Rule 5,7,9 and 10 of the Chemical ' Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 also provide for on-site and off-site emergency plans., as under:

7.3 On-site Emergency Plan :

The plan should include the following information:

7.3.1 The Purpose and Policy :

The purposes of this plan are :

1. To protect persons and properly of your factory in case of all kinds of accidents, dangerous occurrences (Rule 103, Gujarat Factories Rules), emergencies and disasters happening in or affecting your plant at any time.

2. To inform people and surroundings about above happening if it is likely to adversely affect them.

3. To inform authorities including helping agencies (doctors, hospitals, fire, police, transport etc.) in advance, and also at the lime of actual happening.

4. To identify, assess, foresee and work out various kinds of possible hazards, their places, potential and damaging capacity and area in case of above happenings. Review, revise, redesign, replace or reconstruct the process, plant, vessels and control measures if so assessed.

5. To work out a plan with detailed instructions to cope up with above happenings, based on your personnel, equipment and records. Necessary requirements shall be added if not already available. Levels of hazardous substances shall be minimised to the extent possible. Establish machinery for rescue and recuperation operations, total loss control and prevention of harms and recurrence of above happenings. Ensure that absolute safety and security is achieved within the shortest time. Pv~reventior22 and regular maintenance will be useful in this regard..

Each factory shall have to prepare its own plan depending upon own hazards, probable emergencies, personnel, equipment, resources, nearby outside agencies and new requirements if any. Some model guidelines are given below. You may add more points or rearrange as per your own requirement and work out the details.

7.3.2 Site Plan of the Factory and Surrounding :

Prepare a plan of the factory premises and surroundings showing therein the areas of various hazards such' as fire, explosion, toxic release etc., and also location of assembly points, fire station oi equipment room, personal protective equipment room, telephone room, first aid or ambulance room, emergency control room, main gate, emergency gates, normal wind direction, north direction, outside fire station, police station, hospital and other services. Mention their distances also.

7.3.3 Types of Overall Emergencies :

Describe types of emergency and how it can arise in or near your plant. Fire (small and big), explosion, toxic exposure, strike, storm, flood and other hazardous possible situations shall be described with reasons. Sources of hazard from outside or neighbouring plants, tanks, structure etc. shall be mentioned. Effect of prevailing wind and population density likely to be affected shall also be considered. Following table shall be drawn up.

Sr. No.	Type of emergency including disaster (Major class)	May arise due to	At (Place)	People and area likely to be affected
1	2	3	4	5

7.3.4 Assessment of In-plant Hazards :

Give details of assessment of in-plant hazards and control measures provided in the following tables:

A. Storage Hazards and Controls :

Sr. No.	Name of the hazardous content and quantity	Type of hazards possible (fire, explosion, toxic exposure etc.)	Place	Control measures provided	Incharge person, phones & address
1	2	3	4	5	6

B. Process Hazards and Controls :

Sr. No.	Name of the hazardous process, operation or situation	Unsafe parameters (Pressure, temp., flow, content, hazardous situation etc.)	Type of hazards possible (Run away reaction, bursting, gassing etc.)	Place	Control measures provided	Incharge person, phones & address
1	2	3	4	5	6	7

C. Other Hazards and Controls :

Sr. No.	Name of the hazards	Reasons of the hazards	Type of hazards (effects possible)	Place	Control measures provided	Incharge person, phones & address
1	2	3	4	5	6	7

D. Inspections, Maintenance and Monitoring :

Sr. No.	Name of the FEE, PPE, scrubber, safety devices and other equipment	Their locations	Period of Inspection	Incharge person, phones & address	Last date of inspection	Date of inspection and Remark

1	2	3	4	5	6	7

7.3.5 Emergency Organisations and Functions :

Prescribe the constitutions and duties of : (1) Alarm raiser (2) incident (spot) controller. (3) Site main controller (Chief Co-ordinator). (4) Emergency team including engineers and experts. (5) Fire fighting team. (6) Gas control team. (7) First-Aid and Health care team. (8) Ambulance and evacuation team (9) Safety officer and (10) Security officer.

Fix names and designations of Head, Deputy and members (as per need) of each of above team (to be informed in chronological order) in all shifts of working days and on holidays. Their names, day and shift shall be displayed on the main notice board and also with the main telephone operator and chief executive on duty. In a small factory employing less workers these duties shall be well distributed. In a small factory only requisite teams may be formed and some duties may be combined.

Following table shall be drawn up :

Sr. No.	Name of the team (Fire, gas, Medical etc.)	Names of Head, Deputy and members with address	Their telephone numbers		Duties and functions of the team	Equipment to be carried by the team and their location
			Off.	Resi.		
1	2	3	4	5	6	7

Members of above teams shall be available during all shifts and holidays. Protective equipment, lifting gears, fire control points etc.; shall be sufficient in numbers and their locations shall be well informed. Necessary vehicles shall be kept ready to shift persons 'in case of emergency.

Main functions of the fire and toxic gas control teams are as follows:

In Case of Fire:

1. All persons are responsible to report section incharge about details of any incident of fire (slight, minor, major etc.) and shall act by all available means to prevent/control it till it is possible. The section-in-charge will work as incident controller.
2. The incident controller shall (a) Order the 'Fire Team' to control it with all its available means. (b) Assess the nature of fire and report in details to the site main controller.
3. The site main controller shall (a) Take all actions to remove/control the fire. (b) Ask the mutual aid services to be ready on demand, (c) Take help of mutual aid services to fight fire, if it is uncontrolled. (d) Report the off- site fire fighting services for help and action, (e) Report to control room for necessary action, (f) Co-ordinate with offsite fire services to control the fire.

In case of Toxic Gas or Liquid Release:

1. All persons shall report about toxic gas or liquid release to section-in charge and shall act to control or reduce it till possible. The section-in-charge will work as incident controller .
2. The incident controller shall (a) Order the 'Gas Team' to control it with all its available means. (b) Immediately report to the site main controller about the type and possible cause and its likely

effect to the people and property, (c) Inform the site main controller for all likely precautions to be taken to reduce its effect. (Isolation, fire fighting services, mutual aid etc.)

3. The site main controller shall (a) Order to all section ;n-charge to control/reduce toxic release by all possible means.(b) Ask Gas Team and fire -fighting services of the factory for necessary control and evacuation in the plant, (c) Report mutual aid agency for help. (d) Operate alarm to warn the surrounding people before it is likely to effect, (e) Report off site fire services.

Similarly duties (functions) of others shall also be described.

7.3.6 Telephone Operators' Guide :

Telephone is the essential communication system. Tabulate all your internal telephone numbers and outside emergency numbers for information and help. If any telephone is torrid not working at a time, a speedy messenger shall be sent. Formulate table-A for all internal phones and table-B for outside emergency phones.

A. Internal Phones :				
Sr. No.	Name of the Department	Phone No.	Main persons available	Residence phones if any
1	2	3	4	5
B. Outside Emergency Phones :				
Sr. No.	Name of the Dept. / Service	Phone Numbers		Address
		Off.	Resi.	
1	2	3	4	5

In table-B, phones of your top executives, fire, ambulance, transport, hospitals, doctors, ESIC, Red Cross, Police, Home guards. Factory Inspectorate, Collector, experts, surrounding factories, power, water, gas, GIDC, Pollution Board and other Govt. authorities, helping associations and institutions etc. shall be included.

Who shall inform the Govt. authority and others that shall be prescribed. Statutory information, if any, shall be sent immediately.

The telephone operator shall give exact information of the place, nature and severity of the emergency and shall not disconnect till the message is repeated at the other end. He shall first hear the message without any interruption and record it. When the message is over, he shall ask the missing links or further information required.

7.3.7 Emergency Shutdown Procedure :

Looking to the gravity of emergency, if it seems necessary to shut down the process or plant, detailed instructions shall be laid down for plant/area.

Following table shall be prepared for each Shed/ Department/Area:

Name of the Plant/Shed/Dept/Area :

Sr. No.	Location & Phone	Necessary shutdown procedure (action)	Generally by whom	Remark

1	2	3	4	5

7.3.8 Link with Off-site Emergency Plan :

To deal with the emergencies extending outside the factory premises and affecting neighbouring area, off-site emergency control procedure and public warning procedure shall be laid down and followed. Information required by the Govt. authorities shall be furnished to make and update the Off-site Emergency Plan.

7.3.9 Pre-information to Doctors and Hospitals :

Antidotes, medicines and remedial measures shall be conveyed to surrounding doctors and hospitals who will verify them before their use.

When any affected person will be sent, information regarding type, time and duration of exposure and antidote shall also be sent.

7.3.10 Printed Plan, Copies and Rehearsal:

The on-site emergency plan so prepared shall be documented in a .typed or printed form in sufficient copies to give to all concerned for knowledge, study and easy follow up. Written notices (emergency instructions) shall be displayed at necessary points. Merely understanding the plan will not be useful, safety is an acquired talent which needs regular exercise. Therefore, the emergency plan shall be rehearsed and practised at regular intervals to test efficiency of personnel, equipment, co-ordinated efforts and to increase the confidence and experience to operate such plan successfully. The personnel shall be properly trained for tills purpose.

7.4 Off-site Emergency (Disaster Management) Plan :

7.4.1 Purposes of the Plan :

Briefly they can be stated as-: (1) To save lives and injuries (2) To prevent or reduce property losses (3) To prevent or reduce damage to environment, and (4) To provide for quick resumption of normal situation or operation.

For further details the purposes are narrated as under:

1. To protect persons and properties of the factories in general and the affected community as a whole.
2. To identify, assess, foresee and work out various kinds of probable hazards, their place, potential, damaging capacity and area in case of all accidents, dangerous occurrence (Rule 102, Gujarat Factories Rules), emergencies and disasters happening in or affecting the jurisdiction at any time. In this regard it coincides with the purpose of on-site emergency plan of a factory, and will go through the on-site emergency plans of all factories in the jurisdiction and will guide or suggest the missing aspects if any. The On-site Emergency Plans will be considered in advance while making and operating this Disaster or Off-site Emergency Plan. Thus on-site and offsite plans together will be single and co-operative 'package' for the common purpose of fighting the emergency. Modifications in the plans and reduction in quantity of materials may be suggested if necessary.
3. To make explicit the inter related set of actions to be undertaken in the event of an industrial accident posing hazards to the community. The plan must be both factual and action-oriented.

4. To inform people and surrounding about emergency and disaster if it is likely to adversely affect them. Machinery will be established for this purpose to guide the people in proper way.
5. To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation.
6. To plan for evacuation, safe assembly points and transportation required.
7. To plan for prevention of harms, total loss control and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest possible time.
8. To contain, limit, localise and minimise the loss and damage to persons, property and environment arised from the accidents on road or industry, transport, storage or otherwise. To plan to decrease the potential levels of risk.
9. To prevent the spread and rehappening of the disaster.
10. To plan for review, rectification or modification of this Disaster Plan on the ground of actual experience.
11. To plan for communication meeting with industries, authorities, experts, institutions, doctors, hospitals etc.
12. To prepare a site plan, identifying industries, hazardous points, control points, assembly points, hospitals, dispensaries, fire station, police station, railway station, bus station, transport points, roads and all other requisite details.
13. To verify the information given by the industries to comprehend dangers and to arrange for adequate personal protective, fire fighting and emergency equipment.
14. To establish command structure and to identify the respective roles of the senior personnel of various service groups, viz. police commandos, experts-group, para medical group, toxicity control and de-contamination squad and various authorities of water, power, gas, health, labour, environment, revenue, explosive, pollution control, press, post, telephone, wireless, radio, TV, railway, transport and social services etc. Necessary representatives of employers and employees shall also be incorporated. Various organisation, their duties, equipment, implementation procedure and actions on-site and off-site, warning system, communication system, co-ordination system, control centres, key personnel shall be prescribed.
15. Plan to carry out training programmes in safety, health and environmental protection for the concerned parties. Necessary publication will also be useful.
16. To maintain full liaison between all parties to this plan, industries, emergency services etc.
17. To plan for the antidotes, remedial medicines and equipment in the hospitals and carry out research for them for latest and effective measures. Sufficient stock and mutual aid scheme will be useful.
18. To provide for continuous monitoring system for essential parameters of pollution to judge malfunctioning at the initial stages and warning systems at appropriate places. Meteorological information regarding prevailing weather conditions, wind velocity and direction, rain and flood data for such data-collection.
19. To appoint a record keeper, historian and staff to collect information on the cause of disaster and to maintain the record thereof and also of the plan proceedings.
20. To carry out mock implementation and rehearsal of this plan to ensure its efficacy, test and response, interaction and co-ordination of operators of various service organisations, evaluate the effectiveness and adequacy of the equipment and to gain experience and confidence to implement the plan. The finalised Disaster Plan shall be given to all concerned for implementation and rehearsal.

7.4.2 Plan of the Jurisdiction with Locational Layout:

Like on-site emergency plan, a map or plan of the jurisdiction (area) with locational details shall be prepared and all necessary points shall be shown for guidance.

7.4.3 Risk Assessment:

Risk assessment is most essential before designing any off-site emergency plan. Hazardous factories and their hazard identification, other hazard prone areas and general and specific risks, , transportation risk, storage risk, pollution risk by air and water pollution, catastrophic risk such as disasters, natural calamities, acts of God, earthquake, landslide, storm, high wind, cyclone, flood, scarcity, heavy rain, lightening, massive infection, heavy fire, heavy explosion, lava/ vulcano, heavy spill, toxic exposure or pollution, environmental imbalance or deterioration etc.; risks from social disturbances such as war, riots, sabotage, bomb-threats, massive strike, great mischief, damaging indiscipline etc., and risks inferred from the past accidents must be considered while carrying out risk assessment for a particular area (viz. district) for which the off-site emergency plan is to be prepared.

Types of disaster to

Sudden Natural	Sudden human-made
Avalanche	Structural collapse
Cold wave	Building collapse
Earthquakes	Mine collapse or cave-in
Floods	Land disaster
Flash flood	Sea disaster
Dam collapse	Industrial/technological
Volcanic eruption	accident
Glowing avalanche	Explosions
Heat wave	Chemical explosions
High wind cyclone	Nuclear explosions or
Storm	thermonuclear
Hail	explosions
Sand storm	Mine explosions
Storm surges	Pollution
Thunder storms	Acid rain
Tropical storms	Chemical pollution
Tornado	Atmospheric pollution
Insect infestation	Chlorofluoro carbons
Landslide	(CFs)
Earth flow	Oil pollution
Power shortage	Fires
Isunami & tidal wave	Forest/grassland fire

Long-term Natural	Long-term human made
Epidemics	National (Civil Stage,
Drought	Civil War)
Desertfication	International
Food shortage or crop	(War like encounters)
Failure	Displaced population
	Refugees

Different groups or comities are formed to do different emergency functions as under :

7.4.4 District or Central Control Committee (DCC or CCC) :

As the off-site emergency plan is to be prepared by the Government, a Central Control Committee or Group shall be formed under the Chairmanship of the area head. For example we assume a district structure and District Collector (is the Chairman of the District Control Committee (DCC). Other officers from police, fire, factory, medical, engineering, social welfare, publicity, railway, telephone, transport and requisite departments shall be incorporated as members. Some experts will also be included for guidance. A table of their names, addresses and telephone numbers shall be prepared.

The functions of this committee should be :

1. To work as main co-ordinating body constituted of necessary district heads and other authorities with overall command, co-ordination, guidance, supervision, policy decisions and doing all necessary things to control the disaster/ emergency in the shortest time.
2. To take work from subordinate committees. If any committee is not functioning at any time, the Chairman shall form a new committee.
3. To take in or relieve members to the DCC or other committees as per need or Government's directions. This will be done by the Chairman of the DCC.
4. To prepare, review, alter, update or cancel this plan and to keep it a complete document with all necessary details. Separate office and staff may be appointed by the Chairman for co-ordination and well functioning of the plan.
5. To take advice and assistance from experts in this field to make the plan more successful.
6. To set in motion all machinery to this plan in the event of disaster causing or likely to cause severe, heavy or massive damage to public, property or environment or as per the direction from the Government. The plan will be executed to control the situation, remove the hazards, save the lives, losses etc. and provide shelter, medical help etc. in the shortest possible time.
7. All members of the Committee shall be reportable to the Chairman and will act with high integrity, well discipline, quick response, sincerity and best co-ordinated efforts. They will attend meetings, prepare records and act in the direction of smoothening the work. The member secretary will act as advisor to the Collector who will conduct all co-ordination work as a District Head of all offices.
8. On receiving information of disaster or emergency from any source, the member to the plan will inform the Chairman or his .subordinate in his absence.
9. On receiving such information the Chairman shall take quick decision whether to operate this plan or not.
10. The Chairman shall immediately inform all secretaries of different committees to be alert and ready and will give necessary order to concerned secretary/members to rush to the spot for their respective work. Only necessary part of the plan will be operated.
11. Public will also be informed about declaration of disaster and necessary instructions for them.
12. The Incident Control Committee, Traffic Control Committee and Press Publicity Committee will first be informed as they are needed first.
13. All committees shall work as per their function and duties and as per their best judgement, knowledge and machinery to control the situation within the shortest time and without creating new hazard.
14. The Chairman shall form a Communication Committee (CC) consisting of his representative and members from Telephone, Information and Railway Departments to use their hot and fastest telephone lines (actually the Collector must have such hot lines) for speedy communication. The CC will carry out all communication with necessary agencies. The CC shall work continuously till the disaster is over and the Chairman disperses it.
15. The DCC will continue the execution till the disaster is over and normalcy noticed. Evacuated, injured or badly affected people will be given necessary help even after the disaster is over. Public will be informed about restoration or resumption of normal situation and cessation of declared disaster. Then the DCC will stop its operation.

16. All committees will prepare and keep ready teams of necessary persons, equipment, instruments, vehicles etc. to carry out their functions speedily, efficiently and to work under their control.

7.4.5 Fire Control Team (FCT) :

Duly qualified and well experienced members shall be taken in this Fire Control Team.

Function and duties of FCF should be :

1. To fight fire, control it and quench it completely. If uncontrollable, to stop its spread and to report to the Chairman for further help from outside. The team should have walky-talky or similar instrument to talk with members and directly with the headquarters.
2. The members here are incharge of fire stations. Therefore, they have their crews, fighters and equipment ready. They should always check that whether their fighters, equipment, staff etc. are of required size, type, number etc. and they are capable of quenching any type of fire.
3. On receiving information from the Chairman, the FCT Secretary or leader will instruct other members also and they will reach immediately to the spot and will extinguish the fire completely. They will not leave the place without the permission of Secretary or Chairman and will also work with outside fire team if it is required to call and such team is working in joint efforts.
4. With the help of Utility and Engineering Services Team the damaged area due to dire or explosion will be made clean and accessible. Power, water, heavy vehicles, diesel pumps etc. will be used as per need.

Flammable Releases :

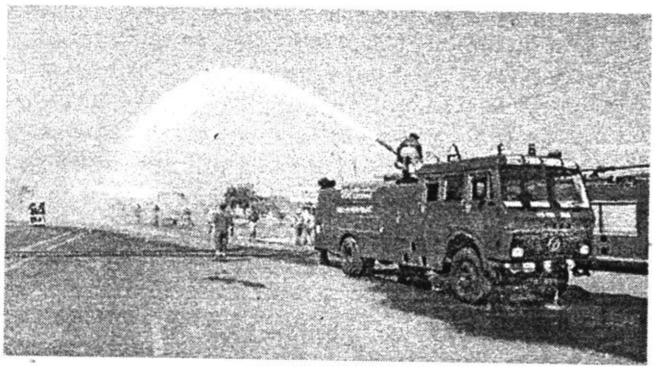
The following examples show how events involving flammable materials may need different planned responses.

(a) A major fire, but with no danger of an explosion e.g. fire in an oil storage tank. The hazards would be prolonged high levels of thermal radiation and smoke. It is unlikely that anyone outside the site would be affected immediately. Only houses close to end directly expose to severe thermal radiation and would need to be evacuated. In some cases it might be desirable to evacuate those areas severely affected by smoke.

(b) A fire threatening a major item of plant or a storage tank containing hazardous 'materials. As part of the on-site assessment the consequences of such an event should have been estimated and the area that it might be necessary to evacuate, determined. Hence the appropriate response might be to evacuate those potentially at risk

(c) A fire similar to (b) above, but developing too quickly to allow evacuation. The best possible response might be to advise people to remain indoors away from windows and shielded from line of sight of the fire. Evacuation should NOT be attempted if there is a significant risk that a fireball or BLEVE could occur while the people were in the open.

(d) For some major catastrophic events that occur without warning, it may not be possible to take prior emergency action. However most such events are of very short duration. The role of the emergency services would be rescue, treatment of the injured, extinguishing secondary fires, etc. If such an event were to occur it might well be that majority of people off-site would be indoors and receive only relatively minor injuries.



Fire Stations and Equipment : Details of all fir(equipment should be kept in an Annexure. Fin fighters/tenders, portable fire extinguishers, fire pump; and engines, hoses, flanges and couplings, crosses asbestos clothing, water jel blankets, risers, ladders reels etc. all necessary equipment including self breathing apparatus shall be included in this Annexure. The FCT will verify this. It may consult TICT (Part 74.6) and DCC (Part 744) for this purpose also

7.4.6 Toxic Incident Control Team (TICT):

Details of the team members shall be tabulated Duly qualified, experienced, expert and responsible officers should be the members of this team. Expert on chemistry, chemical engineering, health and hygiene, safety etc. are most useful. Officers of Police Power, Pollution Control, Revenue etc., are also necessary for incidental work. If such experts are no available in Government, they should be incorporated from the private sector within the district.

Functions (aims and objectives} of this team and duties of the members should include :

1. Main function of this team is to control the gas leakage, poisonous spill and air or water pollution. Any toxic gas or its air mixture, vapour etc. or spill of dangerous goods-solid, liquid or gas, poisonous spray, flow, water, soil, or environmental pollution severely affecting the jurisdiction are the main subjects of this committee. The members shall make all preparations to control such toxic exposures.

2. This team is headed by the secretary or a team leader. The District Collector is common i.e. only one Chairman of all such teams. All members are reportable to him. They will act under his guidance and report him about their work and findings. The Secretary will work in advisory capacity. The Secretary will keep necessary Annexures at his residence also.

3. The team will keep the list of toxicity control equipment. Many small factories, though of hazardous nature, cannot afford all such equipment because of their high cost.

4. The team will maintain a crew (group) of well trained persons with all safety equipment necessary and with tools, vehicles, etc. to detect, control and' stop completely all types of toxic exposures. This crew will accompany the team while going to combat the situation. The team will select such persons and maintain the list of their names, address, phones, arrangements to -call, and places of control equipment etc.

5. On receiving information from the Chairman to, rush to the place of disaster, the secretary and other members will reach the place with crew (in para-4) accompanying or just following and try to control the situation. They will find out the source of toxic exposure and will stop, close or remove it to a safer place if possible. They will also try to neutralise, inactivate or detoxicate the toxicated zone, localise and limit the spread of disaster, stop further development of chain reaction or chain of disastrous events and decrease the levels of material causing disaster.

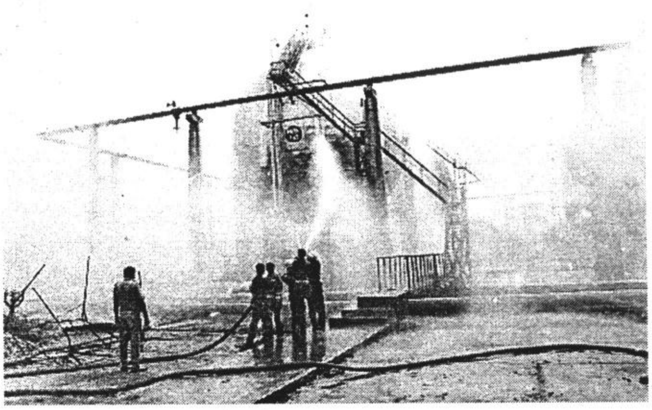
6. The team will advise about the evacuation of people or staying in position whichever and wherever necessary. The members of evacuation team will act accordingly.

7. After the situation is controlled and the danger is removed, the team will record the causes of accident and suggest the measures immediately necessary to return to the safe position and subsequent remedial measures for prevention of accident. The team will submit this report to the Chairman who will send order of 'compliance. The concerned Government officers will also take necessary action under their respective powers.

8. With the help of Utility and Engineering Service team the exposure/spillage area will be made clean and accessible. Power, water, heavy vehicles, diesel pumps etc. will be used as per need.

9. If the team finds that the disaster is uncontrollable by them, they will report the Chairman for external help from the Government and other agencies. The TICT should have walky-talky or similar instrument to talk with the members or directly with the head-quarter. The Chairman will immediately arrange for such external help available from wherever possible.

Toxic Release Control:

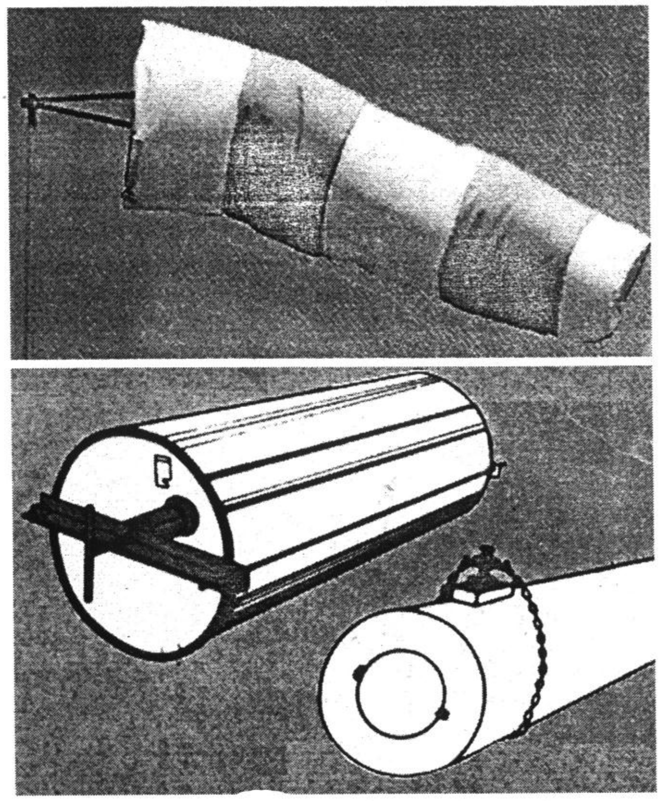


The following examples show how events involving toxic materials may need different planned responses.

(a) A slow or intermittent release e.g. through a leaking relief valve. It would be unlikely that anyone outside the site would be severely affected immediately, although many of the notifiable substances have irritant properties or an unusual smell. If there were reason to foresee that the release would not be controlled quickly, or would grow with time, it might be desirable to evacuate those people nearest to the site of release and most closely downwind of it, provided that this evacuation would, increase their safety.

(b) A fire or mechanical damage that threatened an installation containing toxic material. If the fire could not be controlled and if there was likely to be a reasonable period before over pressurisation or plant failure occurred, evacuation might be appropriate, 6nce again priority should be given to those nearest the plant (in all directions) and those in an appropriate arc, e.g. 30°, downwind.

(c) Rapid event with a limited duration e.g. the fracture of a component that could be isolated within reasonable time. Incidents that grow and are rapidly controlled should not be meet by evacuation. Any toxic cloud format would be limited in size and would be likely to drift past a particular spot relatively quickly. The best place for people in the area would be indoors, upstairs, with windows and doors closed.



(d) A major event leading to a sudden release of a large quantity of a toxic substance, which would form a large toxic cloud e.g. release to atmosphere of most of the contents of a storage vessel through the failure of a tank shell, man-hole cover etc. Although the probability of such an event occurring is very low, the consequences would be severe for people living close to the incident and in the path of the cloud. The role of the emergency services would be .rescue, treatment of injured, making safe the affected areas etc. The major difference in releases of toxic and flammable material is the toxic clouds tend to be hazardous down to much lower concentration than flammable clouds and therefore may remain hazardous over greater distances, while travelling with the wind. The consequences arising from release of toxic material, drifting at perhaps 300 meters a minute and dispersing slowly, are difficult to predict. In every case, however, the hazard is greatest close to the source and near the downwind plume. Unless there is a delay, as in (a) or (b) above, the best course might be NOT to attempt evacuation. For those who were not evacuated, but were then exposed to a prolonged release, the chances of survival would diminish with the passing of time. The Emergency Coordinating Officer (in-charge of off-site plan)

Controller of the factory from which the emergency is arised or the nearby factory in case of emergency outside the factory premises, would have to make the quick decision when and how to attempt rescue.

On hearing the major emergency alarm key personnel should report to the Emergency Control Centre or other designated places. Every else should report to predetermined place, viz. their normal place of work, an assembly point or toxic refuge as appropriate to await further instructions.

On hearing the major emergency alarm the Incident Controller (or Deputy Incident Controller in his absence) will contact the Emergency Control Centre to send necessary help at the place of incident. If necessary, he will telephone at places to call essential workers. With the help of essential workers, he will try to contain and control the incident. He may direct to safely close down the plant if necessary. He will inform the action on site to the Site Main Controller and will work under his direction and his own best judgement depending on the situation. He will guide the own fire fighting team and the outside Fire Brigade regarding type of action, extinguishing or controlling material and equipment necessary. He will organise the help from all expert teams as may be necessary. He will prevent the spread and control the situation within the shortest possible time.

Non-essential workers will remain in their plants or go to the assembly points as per direction to them from the Emergency Control Centre or the Incident Controller.

Outside agencies will help and work in consultation with the Incident Controller.

Toxicity Control Equipment : A list of such equipment including personal protective equipment shall be maintained. This list is for the ready use of the TICT. It may be expanded in future for more equipment and more details. As small canister gas masks may not be much useful in higher concentration of toxic exposure, self breathing apparatus and emergency kits must be kept in sufficient number.

7.4.7 Traffic Control, Law and Order, Evacuation and Rehabilitation Team (TERT):

This team is headed by the District Superintendent of Police (DSP, the Police Head) as Secretary for overall control, supervision and guidance and all other Dy. S.P., P.I. and PSI of main police stations as members. Heads of Highway Police Petrol, Homeguards and SRP may also be added if the DSP thinks fit and needs their help.

Functions and duties of this team should be :

1. To control traffic towards and near the place of disaster, to maintain law and order, to remove mischief-mongers and law-breakers, to evacuate the places badly affected or likely to be affected, to shift the evacuated people to safe assembly points and to rehabilitate them after the disaster is over and safe signal is given.
2. The police has to identify the dead, to deal with casualties (including post-mortem procedure if necessary) and inform relatives of dead or injured.
3. On receiving information from the Chairman to rush to the place of disaster, the Secretary (DSP) with necessary staff will immediately rush to the place and make arrangement for necessary functions. He will work in consultation with the Secretaries of TIGT and FCT for the purpose of area to be evacuated or to maintain 'stay-in' position. He may consult the Chairman for further help if necessary and will report the position and functions being carried out.
4. Necessary vehicles, wireless sets, and instruments for quick communications shall be maintained and used as per need.
5. A list of all police control points shall be maintained. All details should be inserted in it and it shall be kept up-to-date and handy.
6. The Secretary may prepare a detailed plan based on his staff and machinery and keep up-to-date to carry out functions mentioned earlier. Such plan will be approved by DCC and then, shall be used for faster control.
7. The help of Utility and Engineering team may be taken, if necessary for the purpose of making the roads and area clean, removing any structure, incidental work for evacuation and rehabilitation, use of water, power, heavy machinery etc.

Police Stations and Chowkies : All -Police Stations, Outposts and the control points including Highway Petrol (Control) points shall be included in an Annexure. It shall be maintained at all such points and at the residences of all members for intercommunication and help. The Secretary may revise it and keep up-to-date.

Assembly Points : These points are intended to accommodate and keep persons evacuated because of the disaster. They will be kept here temporarily till they themselves go elsewhere or till the disaster is over, their original places are made safe and they shall be sent back to those places. This work of bringing them to assembly points and to shift them back for rehabilitation shall be done by TERT who can have help from Welfare, Restoration and Resumption team. Big buildings of schools, colleges, wadies, community halls, social or charitable places, clubs and other institutions may be used for this purpose. Care shall be taken that least disturbance or damage may be caused to their persons, property or daily working. Their previous consent shall also be obtained. Tents may be erected if necessary. People brought to the assembly points are taken care by the Welfare team.

Transport Centres and Vehicles : A list shall be maintained of vehicles which may be needed for the purpose of evacuation, shifting of people and to carry back for their rehabilitation. Vehicle Centres, type, capacity etc. should be mentioned. This table also be kept up-to-date by the TERT. The centres and vehicle owners shall be informed the purpose of their inclusion.

Evacuation Criteria:

For evacuation the following criteria are useful.

An early decision will be required in many cases on the advice to be given to people living 'within range' of the accident-in particular whether they should be evacuated or told to go indoors. In the latter case, the decision can regularly be reviewed in the event of an escalation of the incident. Consideration of evacuation may include the following factors :

(a) In the case of a major fire but without explosion risk (e.g. an oil storage tank), only houses close to the fire are likely to need evacuation, although a severe smoke hazard may required this to be reviewed periodically;

(b) If a fire is escalating and in turn threatening a store of hazardous material, it might be necessary to evacuate people nearby, but only if there is time; if insufficient time exists, people should be advised to stay indoors and shield themselves from the fire. This latter case particularly applies if the installation at risk could produce a fireball with very severe thermal radiation effects (e.g. LPG storage);

(c) For releases or potential releases of toxic materials, limited evacuation may be appropriate down wind if there is time. The decision would depend partly on the type of housing 'at risk'. Conventional housing of solid construction with windows closed offers substantial protection from the effects of a toxic cloud, while shanty houses which can exist close to factories, particularly in developing countries, offer little or no protection.

The major difference between releases of toxic and flammable materials is that toxic clouds are generally hazardous down to much lower concentrations, and therefore hazardous over greater distance. Also, a toxic cloud drifting at, say, 300 meters per minute covers a large area of land very quickly. Any consideration of evacuation must take this into account.

7.4.8 Medical Help, Ambulance and Hospital Team (MAHT):

This team is consisted of doctors for medical help to the injured persons because of the disaster. Injury may be of any type : fire, gas effect, acid burn, poisoning, liquid-spray, swallowing, fracture, skin irritation, damage to target organ, radioactive effect etc., through skin or eye contact, inhalation, ingestion, mucous membrane contact etc. Such injuries may be mostly due to chemicals. Therefore doctors with the knowledge of occupational health, hygiene and effect of such hazard parameters and treatment for such injuries are most useful. As such doctors are rarely available, we have to mobilise and utilise all available doctors in the area. Members of ambulance centres, blood-bank runners, antidotes and medicines traders etc. may also be taken in. The MAHT may expand the list for this purpose.

Functions and duties of this team include :

1. To give medical help to all injured as early as possible.
2. Civil Surgeon, is the secretary or team leader who will organise, his team. He may take help from the District Health Officer (DHO), and other surgeons, consultants and experts.
3. On receiving information from the Chairman to rush to the spot, he will immediately inform his team and will proceed with all necessary equipment, medicines etc. as early as possible. The Chairman, shall simultaneously inform DHO and DHO will also start similarly. Civil Surgeon and DHO, both, will co-ordinate their efforts with the help of other doctors they think necessary.
4. First-aid and possible treatment shall be given on the spot or at some convenient place or assembly points and the patients may be advised to shift to the hospitals for further treatment. Ambulance vehicles shall be kept ready and used for this purpose.
5. All efforts shall be on war basis to save maximum lives and to treat maximum injuries. The Secretary shall employ' sufficient doctors, equipment etc. for this purpose.
6. All members shall increase their knowledge to treat health hazards due to various chemicals.
7. Continuity of treatment shall be maintained till the disaster is controlled and the flow of injured is stopped. The secretary shall manage for this.
8. Sick and injured persons kept at assembly points shall also be. treated for medical help.
9. The Secretary shall report to the Chairman of work done and for further help if necessary. His team will leave the place only after the Chairman's permission.
10. The Secretary may prepare a detailed plan based on his staff and machinery and keep uptodate to carry out functions mentioned above. Such plan will be approved by the DCC and then shall be used for better treatment.

Doctors, Hospitals, Health Centres, Blood Banks etc. : A list will be maintained for ready-reference of MAHT and others. The MAHT may modify this to include more details.

Ambulance Centres and Vehicles : This will also be listed for the use of MAHT who may modify it to include more details. The whole Disaster Plan aims mostly to protect human life and injury. Therefore this team will play the vital role.

7.4.9 Utility and Engineering Services Team (VEST)

Without the help or regulation of. utility services of water, power, gas, fuel, coal, steam etc. and that of engineering services of special vehicles, tools, equipment and trained team, efforts of fighting the disaster will not be succeeded. Therefore members of this team should be selected from such departments or services and listed. The Executive Engineer (Road and Buildings), Executive Engineer GEB, Municipal Commissioner or Chief Officers of Municipalities, Officers of GIDC, Transport, S.T., Railway, Boiler and private workshops are included. The list may be modified by the DCC if necessary.

The functions and duties of this UEST should be:

1. To check, regulate, divert or stop the flow of electricity, water, gas, petrol, diesel etc. for the purpose of cutting of the source of danger or to supply them for better control, to run diesel

engines and pumps etc. or to divert them for urgent need or to help the victims, to run vehicles and fire fighters to control disaster, to supply lift, hoist, crane, bull-dozer, heavy trucks, tankers, tractors, tools, labour etc. wherever necessary for the speedy control of disaster and also for the subsequent services necessary to restart and restore the original activities. It shall be ensured that the loss will be minimum. The team may add more functions and duties for varieties of engineering and utility services.

2. The UEST will keep up to date lists of heavy vehicles, power, water and gas centres and may add more details if necessary.

3. The UEST may also work out a plan to coordinate and regulate all such services for speedy execution and such plan shall be approved by the DCC.

4. Various trained teams will be maintained for different jobs. Lists of such teams, workers, vehicles, equipment, machines, tools, their incharge etc. shall be maintained to accompany.

5. On hearing instructions from the Chairman to go to the place of disaster or other control place, the Secretary or team leader will give necessary instruction to respective member and both will go there with their teams, vehicles, equipment etc. as per need. They will carry out necessary functions and report to the Chairman for work being done or further help from outside if necessary. The members will be reportable to the Secretary and the Secretary to the Chairman.

6. After the work is over all teams, vehicles, equipment etc. shall be returned to their original places and well maintained for reuse. The work shall be carried out on war-basis without wasting the time.

7. Utilities to run the vehicles, machines and services shall be preserved in sufficient stock.

8. The UEST will maintain liaison with TICT, FCT, MAHT and WRT for area of work and high need centres. Help of workers of WRT may be taken in exceptional cases and with permission.

Heavy vehicles, lifts, bull-dozers etc. : Its lists shall be maintained.

Power Control Centres : This is the list and details of GEB and other power stations, sub-stations, distributing and control centres. Further details with map shall be maintained up-to-date by UEST.

Water Control Centres : This is the list and details of all big water tanks and pump-rooms of GIDC, Municipalities etc., canals, reservoirs, dams and all big water control centres. Further details with map shall be maintained up-to-date by UEST.

7.4.10 Welfare, Restoration and Resumption Team (WRT) :

At the time of disaster many people may be badly affected. Injured people shall be treated by MAHT but those not injured but displaced, kept at assembly points, dead, those whose relative or property is lost, houses collapsed and in need of any kind of help due to disaster shall be treated by this WRT. Therefore the officers of such departments and welfare institutions arc included here

Functions and duties of this team should be :

1. To find out persons in need of human help owing to the disastrous effect. They may give First-aid from doctors. They will serve the evacuated people kept at assembly points. They will arrange for their food, water, shelter, clothing, sanitation, cleaning up the area, washing, urinals, latrines, bedding, lighting, vehicles or guidance to reach to railway or bus stations, hospitals and other

needful or useful places; for removal and disposal of dead bodies, for help to sick, weak, children and needy persons for their essential requirements etc.

2. The team will also work for restoration of detached people, lost articles, essential commodities etc. The team will also look after the restoration of government articles. Such help may last for some time even after the disaster is over.

3. The team will also ensure that original activities, services and systems are resumed again as they were functioning before the disaster. This is the last activity of this Disaster Planning. The operation/execution of this Plan will be stopped only when this team certifies that the disaster is over and it is verified that all possible activities and services have restarted or resumed and the public life is safe and normal. The team will decide the details for this purpose and will work out a plan of check points. The plan will be approved by the DCC.

4. In carrying out above functions, help will also be taken from various social and voluntary organisations like Red Cross Society, Scout, NCC, Homeguards, Rotary Club, Lions Club, Sports Club, Junior Chambers, Youth Hostels, and so many servicing societies, unions and associations.

5. On receiving information of disaster from the Chairman, the Secretary or team leader will inform all members and organisations to reach to the spot. He will systematically organise and coordinate their work so that no overcrowding, overlapping, duplication or deficiency is noticed.

6. This team will arrange its own vehicles or vehicles of above organisations. Volunteers of different organisations may use their own vehicles. If the vehicles kept for other teams to this Plan are free or permitted, they may be used in exceptional cases.

7. The WRT will work under the supervision of its secretary who will report to the Chairman for work being done and further help if necessary.

Social and Voluntary Organisations : The names, addresses, telephone numbers of members and type of help available from such organisations etc. are to be kept ready.

7.4.11 Press, Publicity and Public Relations Team (PPPT)

The public has right to know about the disaster and the steps being taken to control it. This should be clone through proper channel so that correct information can be given and hearsay or distorted and exaggerated stories do not spread. For this purpose and others this team is formed. Director of Information should be the secretary or team leader and some elected members should also be included for public relations. The team may co-opt more members with the approval of the DCC.

Functions and duties of this team should be :

1. On hearing from the chairman about disaster, die secretary will form a cell in his office for disaster news. He will consult the Chairman about the policy of the news and will follow it strictly.

2. Periodical press-notes will be prepared and given to the news-men, news-agencies, radio. Television etc.

3. The members of the team shall meet frequently for co-operation and good public relations. .

4. Only correct and requisite news shall be given and panic, rumours, hearsay and wrong stories shall be ruled out.

5. All work regarding listing of dead, publishing their number or names if necessary and keeping their record will be done by this team. The family members of the deceased shall be informed.

6. The mediamen may be brought to the area affected or area of work but they will not be permitted to go where safety does not permit.

7. With the help of MP, MLA, Presidents of District Panchayat, Municipalities and other local bodies, respectful leaders and representatives of the people, good public relations shall be maintained for peace, harmony and co-operation from all sides.

8. The committee will also prepare the reports to be sent to the Government.

9. A record shall be prepared and maintained about all facts starting with the disaster till the final resumption of situation. All facts, causes of disaster, account of works done, remedial measures and important aspects shall be preserved as a record.

10. Public will be informed about the start and the end of the disaster with the help of vehicles and instruments.

Vehicles and Public Warning Instruments: A list of all government vehicles immediately available at the call of the Collector are listed here with their departments, phones, addresses etc. Instruments like loud-speaker, walky-talky, cell-phones etc. should be listed. These vehicles and instruments shall be used to give information and instruction to the public. Mostly they shall carry government officers, mediamen, press-reporters, etc. moving for the purpose of the cooperation and co-ordination of all control measures. The PPPT may revise this list for more details and will keep it up-to-date for its functions.

All eight teams classified and described above are important for their valuable functions. A rehearsal shall be carried out to check the usefulness and efficiency of their working and to increase their confidence and experience for such collective work.

7.4.12 Role of the 'Mutual Aid' Agencies :

Various types of mutual aid available from the surrounding factories and other agencies should be utilised, as per need, as a part of the on-site and offsite emergency plan.

Trained staff, equipment, instruments, materials, vehicles, doctors etc., can be available from nearby factories. Agreement with them may be expressed or implied.

7.4.13 Role of the Factory Inspectorate :

The Factory Inspectors are likely to want to satisfy themselves that the organisation responsible for producing the on-site plan has made adequate arrangements for handling emergencies of all types, including major emergencies. They may wish to see well-documented procedures and evidence of exercises undertaken to test the plan.

In the event of an accident, the Factory Inspector will assist the District Emergency Authority (Collector) for information and help in getting mutual aid from surrounding factories.

Factory Inspector may wish to ensure that the affected areas are rehabilitated safely. In addition, they may require items of plant and equipment essential for any subsequent investigation to be impounded for expert analysis, and may also want to interview witnesses as soon as practicable.

The communication system between the factory and various above role playing authorities must be effective. Ineffective public telephone system will not be useful in emergencies. Therefore it should be improved and other effective system like duplex (two-way) radio telephone, wireless set, hot line, cellular phone, emergency lead vehicles etc. should be maintained between important organisations.

E X E R C I S E

1. State, Explain, Mention or Discuss

1. The meaning and types of Safety Appraisal system.
2. Concept of Damage Control and its benefits.
3. Concept of Total Loss Control and its management.
4. Purpose, benefits and procedure of Job Safety Analysis.
5. Job Safety Analysis by giving one example.
6. Safety work permit, its objects, types and content.
7. As a Safety Officer you are told to design a safety work permit. Design one format.
8. Meaning, usefulness and types of SOP.
9. Elements of ISO 14001 OR Advantages of OHSAS 18001.
10. Meaning, objectives and types of Safety Inspection.
11. Meaning and content of Safety Checklist.
12. Meaning, technique and benefits of Safety Sampling.
13. Purposes, process and types of Accident Investigation.
14. As a Safety Officer, you have to design an accident investigation report. Develop one such format.
15. Importance of keeping the records of all the accidents. Prepare a standard format which can be used for keeping records in a uniform way.
16. Types of hazards and their detection techniques.
17. Risk assessment procedure.
18. What is HAZOP? Explain its stages, procedure, objective, team and sequence of working.
19. DOW and MOND index.
20. What is Reliability and Reliability Engineering? State application of reliability engineering.
21. Concept of MAH and its main Objectives.
22. Criteria for the Plant to be under MAH.
23. Role of MAH management of a Plant.
24. Role of Authorities OR Workers OR Public for MAH control.

25. Content of Onsite Emergency plan OR Off Site Emergency plan.

2. **Write Short Notes:**

1. Safety Appraisal System and its content.
2. Safety Inventory System OR Electrical Isolation permit.
3. Product Safety OR Safety Tag System.
4. Hot work permit OR Vessel entry permit.
5. Incident Recall Technique
6. Critical Incident Review Technique
7. Procedures Analysis
8. Methodical Analysis
9. Technique for Human Error Rate Prediction (THERP)
10. PERT and CPM
11. Safety Codes and Standards including ISO 14001 & OHSAS 18001
12. Planning and procedure of plant safety inspection.
13. Safety sampling checklist.
14. Agencies investigating accidents OR Accident analysis.
15. Ten points of Accident investigation report.
16. Risk progression chart.
17. Risk assessment methods.
18. Risk Manager's duties.
19. Risk counters OR Foot prints.
20. Preliminary Hazard Analysis (PHA)
21. Failure Mode and Effect Analysis (FMEA)
22. Hazard file of HAZOP.
23. Fault Tree Analysis (FTA).
24. Event Tree Analysis (ETA).
25. Accident or Cause Consequence Analysis.
26. Maximum Credible Accident Assessment (MCAA).
27. Vulnerability Analysis.
28. "What if" Analysis.
29. Concepts of Critical Equipment and Devices.
30. Components of,-a MAH control system.
31. Requirement of Safe operation of MAH installation.
32. Types and consequences of Major Accident Hazards.
33. Meaning of Gas dispersion and Effects.

34. Types and Effects of Gas Dispersion.
35. Probit Analysis and its utility.
36. Need and Procedure of Safety Audit.
37. Audit Plan.
38. Content of Risk Assessment Report.
39. 'Reasons of Emergency Planning.
40. Role of Mutual aid agency.

3. Explain the Difference with -examples between following:

1. Qualitative and Quantitative Safety appraisal.
2. Preventive and Corrective Safety appraisal.
3. Damage control. Loss control and Loss prevention.
4. Job Safety Analysis and Plant Safety Inspection.
5. ISO 14000 and 14001 OR OHSAS 18000 and 18001.
6. General inspection and Special inspection.
7. Safety surrey and Safety tour.
8. Safety Sampling and Safety tour.
9. Hazard & Risk OR Risk Analysis and Risk Assessment.
10. Individual risk, Societal risk and Acceptable risk.
11. Risk transfer and Risk retention.
12. Qualitative and Quantitative Risk Assessment
13. Fire & Explosion.
14. BLEVE,VCE&UVCE.
15. Dust cloud explosion and Flammable vapour cloud explosion.
16. Safety report. Safety Audit report and Risk Assessment report.
17. Audit objectives and Audit scope.
18. Onsite and Offsite Emergency plan.

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30 Hazardous Materials Emergency Planning Guide, NSC, Mumbai-22.

31 Technical Guidance for Hazards Analysis, NSC, Mumbai-22.

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45. Emergency Preparedness for Facilities: A Guide to Safety Planning and Business Continuity by David Casavant

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CHAPTER – 20

Safety in Engineering Industry

THEME

1 NEED OF SAFETY IN ENGINEERING INDUSTRY

Man and Machine are two important ingredients of Industrial Safety. Man needs machines which many times bring hazards and accidents. This has created the need of industrial safety. It is most important to eliminate or minimise the contact between men and machines. Machines are the product of engineering and therefore engineering occupies the pioneering place in industrial safety. Without engineering industries, no machine, no guard and no mass production is possible. The history of machine is old and interesting. In Chapter-7, Part-1, old engineering branches of India are mentioned and another historical part is given in Chapter-33. Weapons and vehicles expected by Yajurveda and fixed and movable machines in Kautilya's times were not possible without engineering industry. Modern engineering technology is much advanced and many other industries are dependent on it.

In 1981 out of 72,40,000 workers employed in all factories in India, workers employed in engineering factories (i.e. in NIC group No. 32 to 37) were 24,41,000 i.e. 33.71% Thus about 30% labour force is employed in engineering industry in our country.

In USA, deaths due to machinery are reported, by Accidents Facts. 1997. as under :

Year	1992	1993	1994
Out of	86777	90523	91437
Deaths due to machinery	1037	999	970
Percentage	1.19%	1.10%	1.06%

Table 5.8, chapter-5, causes I to 3 state that there were 28% and 23.64% injuries in engineering industry in 1990 and 1991 respectively.

From Table 5.6, it can be concluded that 31.65% fatal and 23.40% non fatal injuries in India, in 1992, were in engineering processes.

Table 5.22, last row Causation No. 101 to 112 and 122 give total 5008 accidents out of 15683 i.e. 31.93% accidents due to machinery, in 1994, in Gujarat.

Table 5.20 shows fatal accidents as 9.8% in 1996 and 20% in 1997 in engineering industry in Gujarat.

Thus a share of accidents in engineering industry is about 25 to 30% which needs attention.

2 STATUTORY PROVISIONS

Sections 14, 21 to 26,28 to 35, 87, 88 and Chapter IV-A (Sections 41A to 41H) of the Factories Act 1948 and rules made under these sections by the Gujarat-Factories Rules provide safety measures for engineering machinery, processes and accidents. Their details are readily available from the statute book and therefore they are not reproduced here. In short, these provisions are for the safety from dust, machinery in motion, power cutting devices, self-acting machines, casing of new machinery, hoists and lifts, lifting machines, revolving machinery, pressure plant, floors, stairs, means of access, pits, sumps, floor openings, excessive weights, protection of eyes and hazardous processes in ferrous and nonferrous metallurgical industries and foundries, coal industries, grinding or glazing of metals, electroplating of metals, sand or shot blasting and stone or silica processes. Provisions of Rules 54 and 102, GFR are also important.

Under rule 54, schedule 5 for centrifugal machines, schedule 6 for power presses and schedule 7 for shears, slitters and guillotine machines are important. See Part 4.4 of Chapter-14 for details.

Under rule 102, Sch. 24, 25 and 26 provide detailed safety measures for welding/cutting, pottery and foundry operations.

See Part 5.1.3 for Sch. 26, and Part 7.1.3 for Sch. 74 for p-a.s welding and cutting.

3 INDIAN STANDARDS

There are numerous IS for various metallurgical and foundry operations, hand tools, portable power tools, machines, mad-line tools etc. A few are mentioned below:

Abrasive wheels 10489
Agitator equipment 9522
Air compressor, 6430, selection 6206, testing 5456
Air conditioning. Safety code 659, terminology 3615
Alloy brazing 2927, steel casting grinding media 6079
Aluminium forging 734, heat treatment of 8860
Aluminising hot dip coating 6697,8508
Anodising 7088
Arc welding 8804

Bag filling machines 9776
Ball mill 4642
Band saw for metal cutting 5030
Belt for pulleys 8531,V- belt 2494,10022, drives 2122, 7923
Blast furnace 8953, 9959
Blasting drilling safety code 4081

C- hook 4164, 3813
Chain driving 1927
Chimney design 6533,1649,4998
Chipping hammer 4915, chisel 402.
Coal cutting m/c 3869, cutting tools 5775, Pulverisers fire safety 2595
Cold forming 5986
Compressed air safety code 4138, air receivers 7938 steel cylinders 8198
Coolant for machine tools 2161
Cooling forging 6272, towers 8581
Copper forging 6912
Corrosion of metals 3531, protection 8062,8629
Cutting tools 10412

Die castings 1655, die forging 9684, die sets press working 10068, dies cutting 1859, rolling 8405, 5702
Drawing office layout and planning 5197, engineering drawing practice 696
Drilling machines portable 5441, bench type 2426, pillar type 2425, radial 6893
Drop forging 5518

Electroplating 3658, 2679,1986,7453
Engineering table hand book SP-6 and 8
Erection of steel work, safety 7205
Ergonomics 10224

Fabrication 7215, 6916
Fan, ventilating 2312, pedestal 1169
Feed for machine tools 2219

Ferrous castings 4843, 7001
Film safety 5431

Warehousing fire safety 3594.
Water - for industry, tests 1622, 3025, 3550, for boilers 10390,1680,1813
Weigh bridges for bulk handling 9777
Weighing machine - automatic 1437, platform 1435, electronic 9281> totalizing 3960
Welding - electrical and gas cutting, safety 818, resistance spot welding 819, fire precaution 3016, procedure approval 7307, 7310, 7318, arc rectifier type 4559, electric 2641 and cutting 812, 6016 arc 6008, cables 9857, welding equipment for eye and face protection 1179, oxyacetylene 1323, protective filter 5983, welder's handbook SP - 12
Wire - drawing 1137, 4913, 9888,
Worm gears - glossary 2567, selection 7403
Zinc alloy die castings 742, electroplating 1073

4 INTRODUCTION TO HOT AND COLD PROCESSES :

4.1 Types of Hot and Cold Processes :

Metallurgical processes are of two types : Hot and Cold processes.

Hot processes are employed to melt ore to make metal, to refine metal and to mould metal in the required shape, section or grade, to make alloy, to weld or cut metal parts and to make tools, equipment, building materials, machine parts, structural parts etc. Fuel-fired or electric furnaces are used for these purposes. Chemical energy of fuel (gas, furnace oil, LDO, wood, coal, lignite, waste etc.) or electric energy is converted into heat in such furnaces. Hot processes include melting, refining, smelting, moulding, forging, hot rolling, welding and cutting, brazing and soldering operations.

See Part 5 for hot working of matal.

Cold processes are employed to further reduce or change the shape, size or section of the hot rolled, forged or moulded metal parts, cut into pieces, drill, bore or grind surfaces, press, punch slot, shear, cut, bend or shape the metal parts' A variety of machines and machine tools are used for these purposes. Hand and foot operated presses, power presses, hydraulic or pneumatic presses, shearing machines, press brakes, cold rolling mills, forming rolls, wire drawing machines and various machine tools like lathe, boring m/c, grinding m/c and modern computerised controlled machines are used in engineering industry.

See Part 6 for cold working of Metal.

4.2 Types of Furnaces, Uses and Safety Measures :

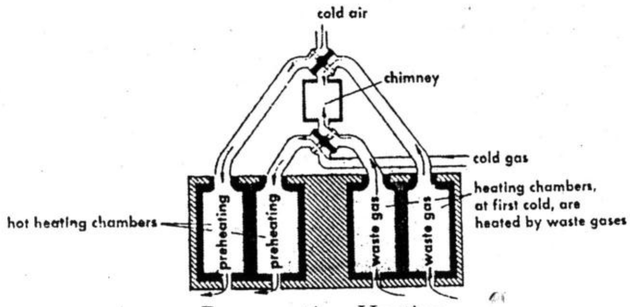
They are classified as under-

(1) Classification based on Structure :

Technologically metallurgical furnaces are classified as melting or heating furnaces.

Melting furnaces are employed to make metals from ores and remelt metals for obtaining the desired properties. Materials processed in melting furnaces change their state of aggregation.

Heating furnaces are employed to heat materials for roasting (limestone, magnesite, refractories, potteries etc.) or drying (foundry moulds, ore, sand etc.) and also for increasing the plasticity of metals before plastic working. They are also used for heat treatment of metals to change the metal structure. Materials processed in heating furnaces remain in the same state of aggregation.



Regenerative Heating

Furnaces may be regenerative or recuperative according to the method the heat of waste gases is utilised.

(2) Classification based on. Heat Generation :

Furnaces are also classified according to the principle of heat generation i.e. either fuel-fired furnaces where heat is generated from chemical energy of fuel or electric furnaces where heat is generated from electric energy.

In fuel-fired furnaces heat is generated by burning fuel on the furnace hearth. They are of two types : flame furnaces and shaft furnaces. In flame (reverberatory) furnaces, the material to be burnt occupies only a small portion of the reaction chamber volume, the rest being occupied by flames and combustion products. In shaft furnaces, all the space is filled with loose charge materials which include lumpy solid fuel.

In steelmaking furnaces (converters), the chemical energy of molten metal is also converted into heat through combustion of impurities present in them. The heat evolved is evenly distributed over the whole mass of the molten metal.

Heat for refining the bath to produce steel is derived from the oxidation of carbon and other elements and no external source of heat is required.

In oxygen process steelmaking furnace, initially oxygen is blown on to the surface of a bath of molten pig iron and steel scrap.

Types of electric furnaces are : (a) Electric-arc 2. and plasma furnaces, single, two or three phase 3. furnaces (b) Induction furnaces (c) Dielectric heating plants (d) Resistance furnaces and (e) Electron-beam furnaces, i.e. micro-wave and infra-red.

(3) Classification based on Operating Mode :

Heat transfer from a heat carrier (flame, electric arc) to the surface of material is mainly through thermal radiation and convection.

Heat transfer from the surface of material into the depth of material occurs predominantly by conduction. But with heated liquids, convective heat transfer is also possible.

Convective mode is typical of low-temperature heat-treatment and drying furnaces. This mode is also employed in heating baths in which a hot liquid is the heat carrier.

Layer wise mode is used in the processing of lumpy materials mostly in shaft furnaces. In such layer wise mode, all three kinds of heat transfer - radiation, convection and conduction - are interlinked so closely that practically cannot be separated from one another. There are three types of layer - dense (filtering) layer, fluidised bed layer and suspended layer of the processed material.

Modern complex thermal plants are usually composed of furnace proper (reaction chamber, burners, electrodes or resistors) and auxiliary equipment (waste gas heater, ventilator, exhauster, stack, valves, gates etc.).

Others:

So far we have discussed the types and uses of furnaces. It is relevant to consider kiln used for cement, lime, ceramic (brick, tile, refractory) and drying purposes and ovens for drying (moisture removal), curing, baking, decorating and solvent evaporation (paint drying).

Hazards and Safety Precautions :

Main hazards while working with furnaces, kilns and ovens are as under :

1. Burns due to contact with hot surfaces.
2. Burns due to contact with hot product, fuel or electricity.
3. Splashing or bubbling of molten metal.
4. Contact of cooling water with the molten metal or slag (e.g. induction furnace) and explosion due to sudden steam generation.
5. Fire or explosion due to leakage of fuel.
6. Carbon monoxide from fuel gas or products of combustion.
7. Explosion due to hydrogen.

Precautions to be followed are as under :

1. Good insulation over hot metal surfaces.
2. Protective clothing for head, face, hands and feet.
3. Respirators, safety eye glass (plain or tinted) for protection against dust, fumes, toxic gases and glare.
4. Exhaust hoods and fans to draw dusts, fumes, gases etc.
5. Good ventilation to vent off hazardous waste generated from scrap charged, alloys and fluxes.
6. Hot work permit before allowing any worker to enter any hot chamber. Ensurance of cooling, fresh air ventilation and lighting necessary.
7. Interlocking to cut off fuel supply in case of flame failure.
8. Precautions while lighting fuel or burner to prevent flash back, fire or explosion.
9. Training and awareness programmes for workers.
10. Provisions of drinking water and shielding to avoid heat disorders.
11. Flameproof electric fitting with solvent drying ovens. PPE against eye and skin irritation or respiratory disorders.
12. Precautions against free silica, asbestos etc., while cleaning and maintaining furnaces. Area monitoring and medical surveillance of such hazardous exposures.

4.3 Steel Manufacture, Hazards and Safety Measures :

Iron occurs very abundantly constituting about 4.7% of the earth's crust. It is the fourth in abundance (first three are oxygen, silicon and aluminium) amongst all the elements. Amongst metals, its abundance is second only to aluminium.

The most important iron ores are iron oxides, carbonates and sulphides.

Three commercial varieties of iron are cast iron, wrought iron and steel. They differ in their carbon and phosphorous content.

Cast iron is the least pure form of iron containing 2.5 to 4.5% carbon with some sulphur, phosphorous, silicon and manganese.

Wrought iron is the purest form of iron containing less than 0.5% carbon and other impurities.

Steel comes in between cast iron and wrought iron. It contains 0.02 to 1.5% carbon and some manganese. Hardness of steel increases with increase in carbon content. Sometimes other elements such as chromium, silicon, nickel, tungsten, vanadium and molybdenum are added to make special steel. Main three grades of steel are as under :

Low carbon (mild) steel - 0.02 to 0.3 % carbon
Medium carbon steel - 0.3 to 0.7 % carbon
High carbon steel -0.7 to 1.5 % carbon

There are many special purpose types of steel in which one or more alloying metals are used, with or without special heat treatment. Some special alloy steels are given in Table 20.1.

Table 20.1 : Some Special Alloy Steels

Sr. No.	Name	Composition	Properties	Uses
1	Chrome steel	2-4% Chromium	High tensile strength.	Ball bearing, cutting tools such as files.
2	Tungsten steel	10-20% Tungsten	Retains hardness even at high temperatures.	Cutting tools for high speed lates.
3.	Stainless steel	18% Chromium & Nickel	Resists corrosion.	Utensils, ornamental pieces.
4.	Manganese steel	10-18% Manganese	Very hard and resistant to wear.	Grinding machinery, safes
5	Nickel steel	2.5-5% Nickel	Resists corrosion, hard and elastic	Wire cables, gears, drive shafts.
6	Molybdenum steel	0.3-3% Molybdenum	Retains corrosion even at high temperatures.	Cutting tools and axles.
7	Invar	36% Nickel	Practically no coefficient of expansion.	Meter scales and pendulum rods.
8.	Silicon steel	15% Silicon	Extremely hard and resistant to acids.	Pumps and pipes for carrying acids.

Carbon steel is the most common, cheapest and most versatile metal used in industry. It has excellent ductility, permitting many cold-forming operations. It is also very weldable. It's normal tensile strength 345 to 485 MPa (50000 to 70000 Ibf/ in^2) permits good ductility. Higher strength is achieved by cold work, alloying and heat treatment.

The temperature at which steel begins to undergo creep, is important. The threshold temperatures at which creep begins are :

Mild steel	-	400 °C
Low alloy steel	-	500 °C
Austenitic stainless steel	-	600 °C

Steel production is an index of national prosperity and the basis of mass production in many other industries such as construction, engineering, automobiles, shipbuilding etc.

4.3.1 Manufacture of Steel :

Steelmaking started in 1855 with the invention of melting process (Bessemer), open hearth process (1864) and the electric furnace (1900). Thereafter the LD (Linz-Donowitz) process by oxygen lance, made it possible to manufacture high quality steel with low production cost.

For large scale production of steel three methods are employed:

1 The Bessemer Process.
2 The Open Hearth Process.
3 The Electric Furnace Process.

These methods are based on removing impurities from pig iron and then adding calculated amounts of carbon, manganese, chromium and other elements.

Forth method, known as Cementation Process is used to manufacture steel in small quantities. It is based on the addition of carbon to wrought iron.

(1) **In Bessemer Process** molten pig iron taken directly from the blast furnace is run into Bessemer converter which a pear-shaped furnace is having holes to blow air at bottom and mouth at top. It can be tilted on horizontal axis.

As the air passes upward through the molten metal, it oxidises the impurities (manganese, silicon, carbon) present in the pig iron.

$$2Mn + O_2 \rightarrow 2MnO$$
$$Si + O_2 \rightarrow SiO_2$$
$$2C + O_2 \rightarrow 2CO$$

MnO and SiO_2 combine to give manganous silicate slag

$$MnO + SiO_2 \rightarrow MnSiO_3 \text{ slag}$$

CO burns with a blue flame at the mouth of the converter. When the whole of carbon is oxidised, the blue flame dies out. The requisite amount of carbon is then added to convert iron into steel. At the end, the converter is tilted to pour out the molten steel.

If cast iron, from which steel is to be obtained, contains much phosphorous, the converter is lined with lime (CaO) and magnesia (MgO) instead of silica. Some lime is also added to the charge. The P is oxidised to P_2O_5 which then forms a slag of calcium phosphate.

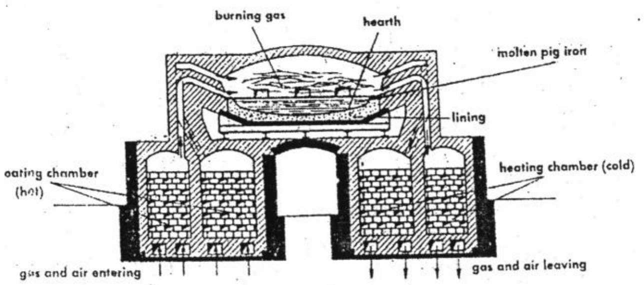
$4P + 5O_2 \rightarrow 2P_2O_5$

$3CaO + P_2O_5 \rightarrow Ca_3(PO_4)_2$

The slag is ground and used as a fertiliser.

(2) In Open Hearth Process, a mixture of cast iron, scrap iron, iron ore and lime is melted in an Open Hearth furnace. The hearth is lined with silica (SiO_2) or calcined dolomite (CaO.MnO) depending on the nature of the impurities (C, Si, S,P) present in cast iron. Heating upto about 1500 °C is continued for 8 to 10 hours. Impurities get oxidised and then react with lime to form slag.

$SiO_2 + CaO \rightarrow CaSiO_2$ slag
$P_2O_5 + 3CaO \rightarrow Ca_3(PO_4)_2$ slag



Open Hearth Furnace

Samples are taken from the hearth from time to time and analysed. The carbon content is adjusted and other metals may be added if special steel is to be made. The finished batch of molten steel is removed by tilling the hearth.

Advantages of the Open Hearth Process over the Bessemer Process are:

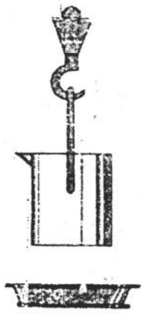
1. Steel obtained is of better quality.
2. Fuel economy by regenerative system of heat economy.
3. Product composition and temperature can be well controlled.
4. Scrap and iron ore can be directly changed into steel.
5. No loss due to air blast through the molten metal.

(3) The Electric Arc Furnace Process : This process involves the setting up a carbon arc. Electrodes are held vertically and the charge of cast iron, scrap iron and iron ore (haematite), mixed with fixed quantity of lime is added in between.

The furnace is usually lined with dolomite. Impurities (C, Si, S, P) are oxidised. Phosphate and other slag (being lighter remain at die top) are poured off by tilting the furnace. After this a charge of coke, lime and sand is added.

$CaO + FeS \rightarrow FeO + CaS$ slag

FeO is reduced to metal by coke (carbon).



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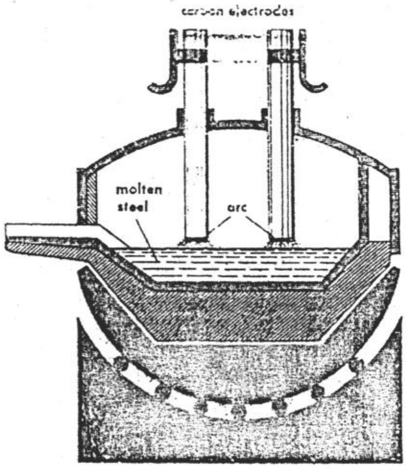


Electric Arc Furnace

As phosphorous and sulphur are almost completely removed, the steel obtained is of good quality. High grade alloy steel can also be obtained by adding requisite alloying metal.

(4) Cementation Process : Bars of wrought iron surrounded by carbon, are heated in "fire brick boxes over 1000 °C for about 10 days. The carbon from the iron surfaces diffuses towards interior and converts iron into steel. Blister steel formed is melted in graphite crucibles till removal of blisters. Other metals are added to confer hardness, tenacity and resistance to corrosion. The steel obtained is known as Cementite Crucible Steel and used to make high grade tools such as razors, chisels etc.

4.3.2 Hazards and Safety Measures :

Main hazards in steel manufacture are as under:

1. Burns due to molten metal, its splashes while tapping, pouring, tilting, falling of ladle and sparks or spatters.
2. Explosion in metal or slag due to water insertion and spattering of hot material over a wide area.
3. Explosion risk in storage, transport and use of oxygen.
4. Accidents due to heavy transport of locomotives, wagons, bogies and rail mounted furnace chargers.
5. Breakage or failure of lifting machines, tackles, ladles, ingots, overhead travelling cranes and unsafe access.
6. Obstructed floors, platforms and stairs with materials and implements.
7. Accidents due to material handling.
8. Poisoning due to Carbon monoxide in fuel gases (converter gas 68-70%, blast furnace gas 20-30% and coke oven gas 5-10%) or its leakage from the furnace, pipelines, water-seal valves, repair work.
9. Excessive heat, heat-stroke and heat cramps (lack of salt due to excessive perspiration) to the workers.
10. Dust generation e.g. sintering near furnaces and in ingot-making.
11. Dense fumes while using oxygen lances or its use in open hearth furnaces.
12. Risk of silicosis to men engaged in lining, relining and repairing furnaces or ladles with refractory bricks which may contain 80% silica. Silicate content causes pneumoconiosis.
13. Eye and ear damage due to glare, high noise of blowers and electric furnaces.

To protect the workers from above hazards, following safety measures are necessary :

1. Engineering measures like guarding and fencing of dangerous machine parts, floors, stairs and platforms, lifting machines, tackles, transport vehicles and safe work practices.
2. Good ventilation, lighting and housekeeping.
3. Efficient exhaust ventilation for removal of dusts, fumes, gases etc.
4. CO detectors should be used to ensure safety: Self breathing or air line respirators should be worn while doing this manually. Fixed CO detectors with alarm are desirable at crucial points.
5. Cold drinking water and salt to worker' working in very hot environment.
6. Rotation of workers after short duration work in hot processes.
7. Ergonomic design of man-machine-environment relationship.
8. Pre-employment medical examination to select suitable persons for hard or hot work, crane work etc. TB disqualifies from work with refractory materials and heart diseases, obesity and chronic gastroenteritis disqualify from work in hot environment.
9. Periodical medical examination of worker; exposed to heat stress, dust and high noise.
10. First-aid centre with necessary medical facilities
11. Safety organisation including safety committees accident investigation and discussion, safety programmes and workers' training is essential
12. Use of personal protective equipment by workers exposed to excessive heat, noise, dust and hot materials.

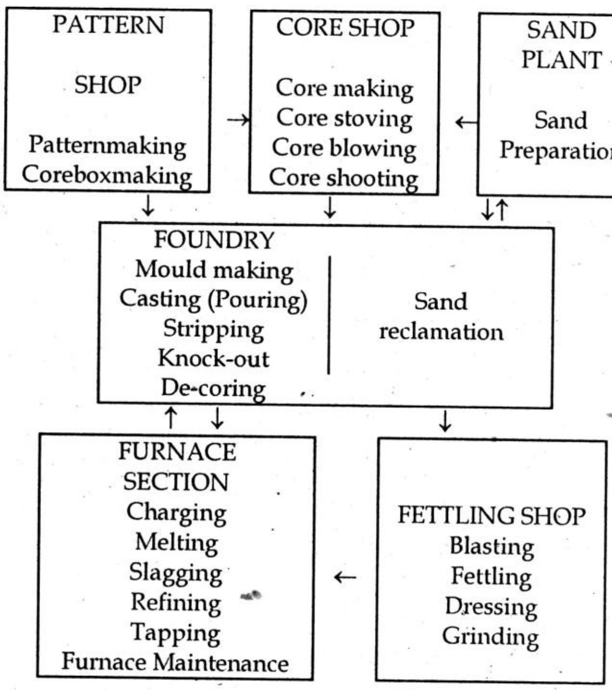
5 HOT WORKING OF METALS:

Hot working of metal includes foundry operations, forging operations and hot polling operations. They are discussed below in brief.

5.1 Foundry Operations :

5.1.1 Flow Sheet;

Foundry process consists of melting metal, sand preparation, core making, pattern making, mould making and then pouring molten metal into a moulding box which is made to the outside shape of a pattern of the article required and contains, in some cases, a core which will determine the dimensions of any internal cavity. A schematic flow chart is shown below:



In course of time foundry process is modemised and mechanised. Wooden patterns are replaced by metal or plastic ones. A wide range of alloys are used as base metal castings. The traditional cast metals, iron, steel, brass and bronze, now contain aluminium, titanium, chromium, nickel, magnesium, beryllium, cadmium, and thorium. New techniques for mould and core making are utilised. In die casting a light alloy is forced into a metal mould under pressure of 70-7000 kgf/cm2 In investment casting, wax pattern with refractory mould is used.

The metal or alloys are melted and prepared in a furnace viz. Cupola, rotary, reverberatory, crucible electric arc, channel or cordless induction type. After metallurgical or chemical analysis, the molten metal is poured via a ladle or directly, into the assembled mould. When the metal has cooled, the mould and core material, if present, are removed (stripping or knockout) and the casting is cleaned and dressed (despruing, shot blasting, hydro - blasting and other abrasive technique). Certain castings may require more finishing, heat treatment, welding, grinding or painting.

Generally an iron foundry comprises six sections:

1. Moulding.
2. Core making.
3. Metal melting and pouring.
4. Knock - out.
5. Fettling, dressing, finishing and
6. Miscellaneous.

The hazards and safety measures in these sections and others are explained below.

5.1.2 Health Hazards and Safety Measures :

They are given below in a Table.

S.No.	Hazards	Safety Measures
(1) Moulding (Preparation of sand, additives and mouldind boxes) :		
1.	Health hazard due to sand, free-silica,	Good housekeeping, local exhaust

	silicones and zircon. Silicosis. Silica dust in sand handling, shakeout and slinging operation.	system on mechanised plant, vacuum cleaning.
2.	Irritation or dermatitis due to Phenolic resins in thermosetting process	Washing with hot water, medical attention on ingestion. Barrier creams.
3.	Asthmatic symptoms due to Methylene biphenyl isocyanate (MBI) used in cold self setting process.	Protective goggles, local exhaust ventilation while dealing with hot sand resin mixture. Clean the storage vessel for 24 h with 5% sodium carbonate solution.
4.	Skin and eye irritation due to sodium silicate in the gas (CO_2) hardened moulding process.	Emergency shower, eye wash bottle, - barrier cream, precaution against CO_2 cylinders.
5.	Fire risks due to isopropyl alcohol sprays on mould surface for better finish. Dermatitis due to such solvent.	Fire retardant protective clothing, hand protection, ventilated booth to prevent organic vapour exposure. No smoking.
7.	Strain due to lifting and shifting of heavy moulding boxes.	Avoidance of excessive weight and using mechanical lifting device.
8.	Hazards of moulding machines and jolt.	Two hand controls, dual safety squeeze controls and knee valve jolt control.
(2) Coremaking (Inserting core of sand and binder into mould) :		
1.	Harmful fumes form core baking oven.	Well maintained chimney.
2.	Pneumoconiosis due to dusting in handling finishing cores.	Dust mask and hand protection to avoid abrasion.
3.	Toxic and fire / explosion hazard where amines are used.	Ample water for washing, FFE, hood extractor to remove fumes.
4.	Core blowing machines, sand blows, hand trapping between core box and ram	Parting lines with dike seal, two hand controls for one operator and four hand controls for two operators, core boxes with handles.
(3) Melting and Pouring (Furnace melted metal is poured into a moulding box through ladle) :		
1	Work near Cupola Furnace-toxic effect of carbon monoxide	Breathing apparatus to b kept ready, emergency work under supervision; Natural and mechanical ventilation.
2	Repair work in furnace	Safety helmet, safety belt while working at height or depth.
3	Tapping i.e. transferring molten metal to a ladle, radiation	Goggles and PPE, refractory or sand floor, care in opening jammed doors, spillage cleaning, mechanical material handling, dry sand to chill hot run-outs.
4	Health hazards due to acrolein, Aluminium, antimony, beryllium, chromium, fluorides, iron oxide fumes and dust, lead, magnesium, manganese,	Local exhaust ventilation \ air dilution by general ventilation, FFE, respirators, aluminium screens against radiant heat, wetting agent,

	phosphorus, SO_2 resins, coal, silica	precautions against lead poisoning, dust explosion and fire, good sanitary facilities, personal hygiene, separate lunchroom and non-contaminated drinking water.
(4)	**Knock- out operation (Removal of rough casting, cores, runners and risers from the moulding box) :**	
1.	High noise over 90dB.	Reduce the noise or use ear plugs or muffs.
2.	Hot sand, dust and metal being separated.	Eye protection and other PPE necessary.
3.	Crushing or breaking of hands / feet etc.	Safety. shoes, gloves, caps etc.
4.	Dust hazard near knock-out grill.	Fine water spray (mist) over the knock-out grill.
(5)	**Fettling, Dressing & Finishing (Stripping away unwanted metal by grinding, blasting, chipping) :**	
1.	Noise of metal hammer for knocking.	Replace metal hammer by rubber covered hammer.
2.	Throwing fragments of hot metal.	Eye and face protection.
3.	Noise of rumbling barrels. (this is prohibited).	Noise enclosure to barrel with local exhaust ventilation.
4.	Pneumoconiosis due to sand blasting.	Sand blasting should be replaced by water or iron or steel shot blasting in a fully closed system with dust extraction system. Wear Blaster's helmet. Warning notice, blasting in separate room. Airless shot blasting is also used.
5.	Hazards of abrasive, polishing and buffing equipment.	Safe operation of machine tools, eye, face, hand and foot protection.
6.	Dusting from dry abrasive wheels.	
7.	Flying objects from cleaning and chipping.	
	(6) Miscellaneous (Pattern making, painting etc.) :	
1.	Noise in pattern making shop.	Reduce noise or provide ear protection.
2.	Hazards of wood cutting and finishing machines.	Guarding and safe operation.
3.	Wood dust from sawing.	Local exhaust ventilation.
4.	Electrical work	Electrical equipment I must be earthed and operated safely. Use PPE. Training for respiratory resuscitation.
5.	Painting, Fire hazard from flammable fumes.	Speedy fume removal. No smoking. Use such paint in small quantity or use water base paint.
6.	General dusting.	Vacuum cleaning, local exhaust system at the point of origin. Water

		and compressed air cleaning (not during or before melting and pouring but after drying only) No misuse or playing of compressed air hose. Vacuum methods are preferred to compressed air cleaning.

5.1.3 Schedule 26, Rule 102 of the Gu)arat Factories Rules, 1963:

1. Applicability:

This schedule is applicable to production of iron, steel or non-ferrous melting and casting by moulds of different materials including the process of shall moulding, die-casting, pressure die-casting, centrifugal casting, continuous casting and making ingots, billets, slabs etc. and the stripping thereof.

It is not applicable to melting and manufacture of lead, electric accumulators, printing press, smelting process, steel ingots, soldering, melting and casting of lead or lead-based alloy to make ingots, billets, slabs etc.

2. Definitions:

Dressing or fettling operation includes stripping and other removal of adherent sand, cores, runners, risers, flash and other surplus metal from a casting to make the surface clean and 'smooth but does not include machining or knock-out operation.

Knock-out operation means removing castings from moulds and also stripping, coring-out and removal of runners and risers.

Pouring aisle means an aisle leading from a main gangway or directly from furnace to where metal is poured into moulds.

Foundry is a place where production of iron, steel or non-ferrous casting (not the production of pig iron or steel ingots) is carried out by. using moulds, including process of shell moulding, centrifugal casting, die casting, preparation and mixing of materials, preparation of moulds and cores, knock-out and dressing or fettling operations.

3. Parting Materials:

Material containing more than 5% silica and dust or matter deposited from fettling or blasting process shall not be used as a parting material.

But natural sand, zirconium, calcined china clay, aluminous fireclay, fused alumina, sillimanite and divine can be used as parting material if free from silica.

4. Store, Floor and Cleanliness :

1. Moulding boxes, ladles, patterns, plates etc. shall be placed without unnecessary risk.
2. Racks, bins and suitable receptacles to be used to put heavy articles.
3. Floor of even and hard surface.
4. Wall height upto 4.2 mt or more should be effectively cleaned once in 14 months.

5. Safe and adequate space for manual work involving molten metal. It should be free ffom obstruction.

5. Gangways and Pouring Aisles :

Gangways should be of even surface, hard material and free from obstruction. Their minimum width should be as under :

If not used to carry molten metal - 0.92 m.

If used to carry molten metal

1. Where truck ladles are used - 0.6 m wider than the overall width of the ladle.
2. Where hand shanks are carried by I or 2 men - 0.92 m.
3. Where hand shanks are carried by more than 2 men - 1.2 m.
4. Travel in both directions by men carrying hand shanks -1.8m.

Pouring aisles should also be of even surface, hard material and free from obstruction. Their minimum Width should be as under -

1. Molten metal carried by I or 2 men per ladle - 0.46 m.
2. If mould remains at 0.51 m height from the floor - 0.6 m.
3. Molten metal carried by more than 2 men per ladle - 0.76 m.
4. Molten metal carried in crane trolley or truck ladle - safe width.

If the workroom or floor is made of sand, above width restriction is not applicable.

6. Work Near Cupolas & Furnaces :

Safety distances of 4 mts. from the delivery spout or 2.4 mts. from ladle are suggested to work near molten metal.

7. Dust and Fumes :

Open coal, coke, wood or stoves may be used if their fumes have safe discharge.

Knock-out and fettling or dressing operations to be carried out in a separate room or under effective local exhaust ventilation.

Ventilation plant should be properly maintained, examined weekly by a responsible person and yearly by a competent person with its report in Form No. 26-A.

8. Protective Equipment:

Hand gloves suitable for hot work or rough work, approved respirators, suitable footwear or gaiters for risk of burns and screens for safety against flying material shall be provided to the workers. Storage accommodation shall also be provided.

9. Washing and Bathing Facilities :

1. Wash place under cover with 0.6 m length for every 10 persons, or stand pipes spaced at least 1.2 mts. apart.
2. At least 50% of wash places should be in the form of bathrooms.
3. Sufficient supply of clean water, towels, nail brushes and soap.

Above facilities should be in charge of-a responsible person and in clean and orderly conditions.

10. Medical Examination:

1. Appointment of a qualified doctor approved by the CIF, with medical facilities given to him.
2. The Certifying Surgeon shall examine a worker within 15 days of his first employment. Allotment of work only after fitness certificate in Form No. 27-A by the Certifying Surgeon (CS).The first test includes pulmonary function test and chest X-ray.
3. Re-examination by the CS every year. Record in Form No. 20.
4. Re-employment of unfit person if the CS declares him fit.

11. Other Provisions:

1. Knocked out burnt sand and other waste to be disposed off safely and quickly.
2. Dross and skimming removed from the furnace shall be placed forthwith in suitable receptacles.
3. Material and equipment left out of doors should not cause risk. Safe means of access, road ways and path ways should be properly maintained.

5.1.4 Material Handling in Foundries :

Ladles should have sufficient strength but not excess weight. Proper balance of hand ladle if desirable. All crane, truck and trolley pouring ladle should have dog or gear mechanism and latch to prevent over turning. Bottom pouring ladles should have stopper mechanism. Preventive maintenance of hoists, monorail, cranes and conveyor to handle moulds eliminate manual handling accidents

Floors, Pits, Gangways and Aisles :

Foundry floors should be kept clean and in good condition and level. Drainage near melting unit is necessary. Water should be avoided here to avoid explosion hazard. To hold down dust, only required water should be used. In molten metal are passageways at least 0.5 m above floor level is safe Pit connected with oven or furnace and floor opening should have a cover or guard. Rail track should be flushed with the floor. Gangways and aisles should have sufficient width depending upon use of ladles crucibles, moulds and persons to travel.

5.1.5 Mechanised Foundry:

Here moulding is done by machine and casting cleaned by shot or hydro blasting. Built-in dust control devices reduce dust hazard. Airborne dust from sand transfer by open belt conveyor poses hazard for which exhaust hood over transfer point or conveyor are necessary. Conveying by pneumatic system provides dust-free system. Die casting involves permanent metal moulds and pattern making is replaced by engineering method such as die sinking wherein pattern making and sand hazards are removed but use of refractory material to coat the die or mould provides some degree or risk. Higher metal temperatures of steel foundry requires coloured lenses for eye protection, dust exhaust system and respirators for dust and lungs protection from silicon dioxide. Alloy founding may give off toxic fume of different metals. Furnace and flue cleaning may also provide toxic exposure. Magnesium foundry poses fire hazard.

Fumes of zinc and copper may cause metal fume fever. Pressure die casting machines present hazard similar to power presses. Mist of oils used as die lubricants and .toxic exposure of fire resistant fluid used in presses are another hazards. All such hazards of alloy founding should be properly controlled.

5.1.6 Non-destructive Testing (NDT) :

Use of X-ray equipment for non-destructive tests of castings is an old procedure. A permanent well shielded location for such tests is necessary. All personnel should wear film badges against X-ray exposure. Because of the different absorption values of different materials, radiographs can be made of objects through the use of X-ray, radium and cobalt60. The activity of radioactive materials is measured in curies. One millicurie is defined as 3.7 X 10' disintegrations of radioactive atoms per second. Radiation is measured by the amount of ionisation it produces in air and its unit is roentgen or milliroentgen. Permissible dose limits should not be exceeded. The pocket dosimeter shows the dosage the person has received during any work period. The film badges and dosimeters both must be used for protection against radioactive tests. Thorough washing with soap and water, protective equipment and never using contaminated clothing into clean areas are desirable for safety.

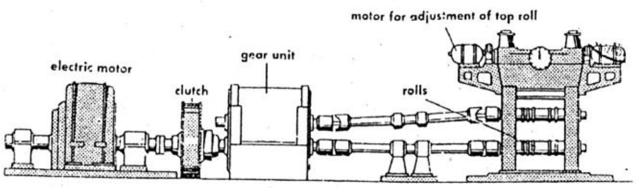
Non-destructive testing is mainly used for detecting cracks or determining the thickness or the quality of weld or metal parts. The methods used are radiography, magnetic particle, dye penetrant, ultrasonic, eddy current and other types.

Detailed information on the theory and practice of non-destructive testing methods is given in reference No. 5 at the end of this chapter.

For details see Part 15.5.2 of Chapter-18.

5.2 Hot Rolling Mill Operations:

5.2.1 Rolling Mill Operations :



Rolling mill with driving machinery

Hot or cold rolling mills cover a variety operations with ferrous as well as non-ferrous metals such as copper and aluminium.

In the rolling mill, the ingots from the soaking pits are first treated in the blooming or slabbing mill to produce blooms, billets or slabs. Then sheet and strip steels are rolled from slab, structural steel from blooms or billets and bars and rods from blooms or billets. In general, hot rolling is used for heavy sections and cold rolling to give desired surface condition with only slight reduction of section. After rolling and cooling if necessary, the product is cut to standard lengths and bundled for dispatch in the finishing department.

5.2.2 Hazards and Controls :

Harmful Gases from lead alloy rolling or cutting, gas cutters, or butt welding (ozone effect), pit furnace and reheating furnace need effective exhaust. Lubricating oil mist, cooling emulsions, degreasing agents for finishing operations, acids in pickling shops and ionising radiation in gauging and examining (nondestructive testing) of metals pose many health hazards. Medical precautions are desired.

In Hot Rolling, looping and lashing may cause burns and severing of lower limbs for which protective posts or other safety devices are necessary. Bridges under roller conveyors are required at crossing points. All hand tools and tongs to hold hot material should be well designed, frequently inspected and well maintained. Ring spanners and impact wrenches should be given to roll changing crews. Splash guards reduce the ejection of scale and hot water. Radiant heat levels may go upto 1000 Kcal/ 2 in hot rolling mills. The infrared radiation may damage upper respiratory tracts. Fans and blowers at hot working places should be so positioned as not to cause chills. Too chilled (less than 10°C) drinks are also not good.

5.3 Forging Operations :

5.3.1 Hazards and Safety Measures in Forging Operations :

Forging Process is used for the plastic deformation of metals and alloys, either hot or cold by applying the compressive forces. Hammer or impact forging exerts multiple forces while press or roll forging excretes single force. Hammer and drop forging are carried out on hot metal only, while press forging is also possible on cold metal. Forging may be carried out manually or mechanically.

Accidents in forge shops are generally due to hot and cold metal coming out, falls of the tup, accidental starting of the machine, crushing hazards, radiant heat, burns, high noise etc. Forge workers may suffer chronic rheumatism, digestive disorders (enteritis), inflammatory skin disease, respiratory trouble and hearing loss due to high noise and vibration.

General Safety Measures are : Good plant layout, uncongested machine and process layout, good housekeeping and ventilation, good draft to furnace and efficient exhaust of gases, water curtains and reflective or insulating screens for protection against radiant heat and hot air, local exhaust systems at the furnaces, cold air showers at hot work places, noise absorbent panels and deep and massive foundations to suppress vibrations. Rest rooms protected against radiant heat should be provided and equipped with air and water showers etc. Comfortable conditions are 19° to 24°C (not exceeding 27°C) air temperature, 30 to 50% relative humidity and 0.5 m/ s air velocity. Protective heat-resistant armlets, gaiters, aprons, safety footwear, eye and face shield, ear muffs or plugs to workers and their pre-employment and periodical medical examinations and safety training are also necessary.

Specific safety measures in forging operations are as follows :

Raw Materials :

In the sequence of forging operations the fist stage is receiving, storing and preparation of raw materials for actual forging process.

Receiving : Raw material, in bars of various lengths and shapes, is received by railway wagon or automobile truck. Unloading operations should be carried out safely under the experienced supervision. Mechanical lifting and carrying should be preferred.

Storage : Adequate storage facilities should be provided with overhead crane or hoist arrangement for safe mechanical handling. When piling is done in racks, retaining posts separating the different types of material should be used to retain maximum load. The bundles should be separated by tie timber of sufficient strength to prevent being crushed or broken. Spacers should be placed between bundles to facilitate the booking up of slings.

Handling : The handling of bar stock in storage areas creates specific hazards, which must be prevented. Most storage areas have overhead cranes and either the electromagnet or the sling suspension method to carry.

Electromagnet is permissible where the storage area is isolated from general manufacturing area or separated by walls and fences which will control exposure to plant-personnel not assigned to the handling operation. The magnet should be energised by a reliable constant power circuit, which is separate from the crane control circuit. Controls should be equipped with a switch that can be locked in position. The temperature of the magnet should be closely watched as its capacity drops as temperature rises. The magnet must be lowered to rest and power to magnet must be-off at all tunes, when the crane operator is not at the controls.

Shearing and Cutting : Most bar stock is reduced to forging multiples as per requirements of forging. Some multiples are cut by metal saws. Saw tables for bar stock must be substantial and should be provided with rollers or slides to assist in positioning for feed to the saw and for transferring cut multiples from the machine. Transmission parts should be adequately guarded. The wheels and all moving parts of band saws should be metal encased. Sliding or adjustable guards should cover the blade of circular saw and band saw with the exception of the point of operation.

Forging Furnaces:

Various types of furnaces are used to preheat metals before forging. The principal furnaces used are the box, pusher, rotary and slot type.

When lighting the oil fired furnaces, a lighting torch should be provided and placed on the furnace hearth near the burner opening where the mixture of oil and air will strike the torch flame. The operator should stand clear of the furnace openings so as not be exposed to possible flash back. With gas fired furnace, the charge and discharge doors should be opened and the furnace purged to remove any concentration of gas. Pilots should then be lit after which the burner may be turned on slowly, making sure that each burner is operating before proceeding lo the next. Furnace doors should be left open until the walls of the heating zone becomes a cherry red. If the furnace is not equipped with pilots, it should be ignited by means of a gas torch inserted through an opening in the furnace wall or burner block near the burner opening. This should be done before the burner valve is opened. Those assigned to light-up operations on either oil or gas fired furnaces should wear clothing that is free from flammable greases or oils to prevent setting it on fire. He should wear proper eye and a face protection (safety spectacle with side shades and a face shield) and a safety hat.

Both gas and oil presents fire and explosion hazards. Whenever the odour of gas is detected, checks should be made to locate the source. Only a gas detecting instrument or a solution of soap and water should be used. The use of any type of ignition only adds to the hazard already present by introducing the possibility of an explosion. Should a leak become ignited, do not attempt to extinguish it until the fuel source has been shut off. This will extinguish the flame as the fuel becomes exhausted. In addition to any safety valves which may be installed, all fuel lines should be equipped with easily operated manual valves installed at the floor level. They must be readily accessible and plainly identified. The floor area at the valve should be kept clear of stock or other material. Due to vibration set up by the impact of forging equipment, leaks in the fuel lines are a common occurrence in the forgeshop and should be repaired as soon as detected. Regular inspection schedules should be set up by the maintenance staff to locate and repair fuel line leaks.

Forging furnace should be shielded as much as possible to protect employees from radiant heat. This can be done by means of asbestos covered screens, metal shield backed by refractory material and stainless steel or aluminium sheets having radiant heat reflective qualities. A water or airline installed along the bottom of the furnace opening,, drilled with small holes in it, will help curtain the heat. Movable plates suspended from a rod across the furnace opening will help control radiant heat. These plates must be free to slide along the supporting rod so that operator as he needs, may move them back and forth at the furnace opening.

Electrical hazards around forging furnace exist due to the breakdown of wiring insulation because of exposure to heat and moisture. Prompt repair of defective wiring will reduce the hazard. Electrical cables should never be permitted to lie on the floor where they may be run by trucks, damaged by stock containers, dies or hot forging.

Furnaces should be equipped with safety disconnect switches that can be locked out when repairs are made. Carbon monoxide detectors with alarm, and other instruments which will reveal the presence of harmful gases should be used to check out a furnace before employees are permitted to enter. The fuel lines should be disconnected or sealed to prevent fuel running into the repair areas inside the furnace. Permit-to-work system should be adopted. There should be main safety switch in the primary power source ahead of fuses that can be. locked out.

Excess smoke from the oil fired furnaces should be exhausted by means of an exhaust-ventilation system and furnace hood. Cooling fans are necessary equipment in the forge plant but can be die cause of many serious accidents. The fan blades etc. should be adequately guarded with sturdy wire mesh guards. Up right conduit extension for electrical cable should be provided which would keep the cable off the floor. Fire extinguishers, suitable for oil fires, should be available for use in areas where oil is used. Rigid house keeping standards should be set up and followed. Oil absorbent compounds should be used on floors to reduce fire and slipping hazards.

5.3.2 Preventive Maintenance of Forging Machines :

Forging Hammers :

In most of the forge shops, drop hammers are used. These can be classified into board drop and air or seam drop hammers depending on the means or method of power transmission.

Treadle Guard : The operating treadle should be guarded to prevent accidental depressing of the treadle. It is important that the treadle guard be well designed to provide complete coverage and at the same time allow enough clearance for operator comfort and control of the treadle action.

Overhead Bolts : Because the steam or air drop hammer is a heavy impact machine , there are several internal and external stresses occurring in the hammer structure during -the forging process. Continued stress and vibration causes metal fatigue of the critical parts of the hammer. One cannot predict the life of these parts, so it is important that protective safety measures be taken to guard against the falling object hazard. Parts that frequently fail are head bolts, cylinder bolts, guide bolts, cylinder bolt springs, column bolts and gland bolts. These parts should be retained and prevented from falling by installing safety cables or chains.

Power Transmission Parts : In the case of board drop hammers, all exposed power transmission parts be well guarded. This includes the flywheel, drive belts, motor pulley and drive coupling etc.

Scale Shields : Complete confinement of scale is necessary if serious burns and eye injuries are to be prevented. Portable shields should also be used when driving out die or some block keys to prevent injuries by a die key flying out into the working area.

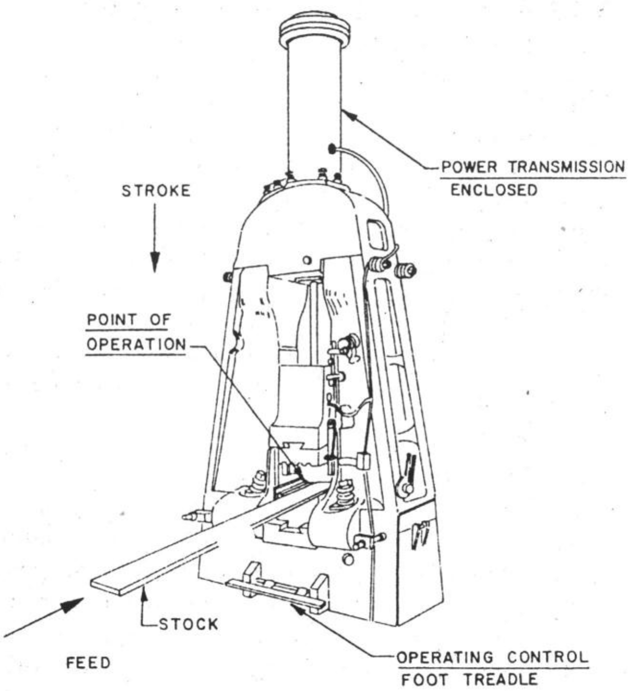
Safety Head : All steam or air drop hammers should be equipped with a safely type cylinder head designed to cushion the impact blow if the piston breaks or pulls out of the ram.

Start up Precautions : In starting a steam driven hammer, the exhaust valve must always be opened first and then die main steam valve. This must be done very slowly to prevent damage to the cylinder head. If it were opened rapidly, any water (condensate) in the cylinder could not escape as rapidly as the steam. Therefore, driving the piston against this water would put undue shock on the cylinder head. A full stroke of the piston must not be made until the water on both sides of the piston has been blown away. This is accomplished by taking short partial strokes.

Other Precautions : Air or steam valve should be closed whenever the hammer will not be used for considerable length of time. The ram, piston rod and dies are much more likely to be broken when cold.

Maintenance and Inspection : For complete dismantling and overhaul of a hammer as well as day-to-day maintenance, select tools and rigging equipment carefully. Because hammer parts are extremely heavy and bulky, employees must be fully trained in heavy rigging and repair work. A well planned inspection and preventive maintenance and accurate up-to-date records of replacement parts are necessary. Hammer equipment is usually hot and slippery thus creating a hazardous condition if proper facilities are not provided. Proper rigging equipment, hand tools, hoisting equipment, ladder and platforms should be available. Permanent platforms at overhead for hammer repair and adjustment areas are absolutely necessary.

Forging Press:



Forging and hot metal stamping

Due to its basic design, the forging press falls within the classification of power presses and hence hazards involved are similar to those of power presses. Therefore its maintenance is also similar to that of a power press. See part 6.2.2.

Trim Press:

Some forging have a rim of excess metal called flash. It must be removed by trimming (shearing) the metal either while it is still hot from forging operation or after it has cooled. This work is done in Trim Presses. Hazards and precautions involved are similar to power presses. See part 6.2.2.

Horizontal Forging Machines:

Horizontal forging machines are also called headers or up setters. These machines are designed for forging bolt heads etc.

Guarding : All parts of the machine except the feeding area should be entirely enclosed. Access doors may be cut into the enclosure in order to serve or lubricate moving parts. Movable section of guards should be interlocked so that the machine cannot be operated until every thing is in proper place. To prevent accidental tripping of the operating pedal, it should be enclosed.

Die Setting and Repairs : When dies are changed, repaired or adjusted, all power should first be shut off and locked out to prevent accidental starting. When the flywheel is completely stopped, dies open, and the header slide is completely back, the dies should be removed. Dies for new set up are usually lowered into the machine with a pry bar. It is good practice to make the set-up according to die layout.

5.3.3 Safe Work Practices in Forging Operations:

Stuck Forging:

In the event of stuck forging, the proper knock out tools and techniques should be applied. The tools should be made so that they are easy to handle and hook safely either around a die block or on the back of the die to prevent kick-back. They should bemade from soft steel and receive proper care, inspection and maintenance. Die liners, flash, wrenches or bars should never be used to remove stuck forging. Cold steel should never be placed between dies to dislodge stuck forging--

Suspended Chains and Trolleys :

Because forging operations require a great deal of stock movement (such as from furnace to hammer to press to conveyor) overhead trolley with suspended chains or tongs and hoist for heavy material are used to great advantage. Equipment including hoists, slings and chains should always be kept in good working order by periodic inspection and preventive maintenance schedules.

Props and Catches:

Props mid catches used during productions : Loose props should not be used. To support the ram between forging sequences on hammers, mechanical props or catches attached permanently to the hammers should be used. There are two main types: counter balanced props and fork catches. Fork catches have the merit of giving maximum engagement when supporting the ram, but they suffer from certain mechanical disadvantages and prone to failure, if not effectively maintained. Ends of the prop should be absolutely flat for better support.

Props used during die changing : With all types of hammers the ram has to be supported in a raised position during die changing, and the usual method employed is to use a prop. Every hammer should have its own die changing prop, which have an identifying mark on it and should be secured to the hammer. Props should be used during die changing in hammers with automatic or pneumatic hold-up gear. Accidents have occurred when the ram has been kept in raised position by held up gear (in case of steam or pneumatic hammer, by pressure). Inadvertent tripping of the hammer pedal has caused the ram to fall and serious injury to the person setting. An additional and much safer precaution is to switch off power or close securely all main supply valves on air and steam hammers and support the ram by a properly designed and maintained prop.

Tongs:

Tongs are the basic handling tool of the forging trade and, because of their tremendous impact force, they can cause serious accidents. How well the tongs are handled by the operator and how well they fit to the forgings are factors which control this hazard. Light weight tongs, properly fitted to stock or forging, are recommended. Tongs should be of sufficient length so that handles cannot kick back and cause injury. They must be handled and held properly to prevent finger and hand injuries. To help prevent forging or billets from being dropped during handling, the tongs bits must be properly fitted to the tong hold. When riot in use, tongs should be stored on specially designed tong-stand. Replacement tongs must be readily available to discourage employees from using worn out tongs.

Personal Protective Equipment:

Personal protective equipment for forge shop employees include safety shoes, leather leg guards, safety helmets, hand and arm protection, leather aprons, etc. Goggles with coloured or clear lenses, face shield or wire mesh face screen should be worn to help prevent face and eye injuries. Aluminised asbestos cloth overalls should be provided to furnace men to protect them from radiant heat. Ear muffs or ear plugs should be provided to forging crew to protect them from noise.

5.3.4 Safety in Use, Handling, Storage and Changing of Dies :

Die Design : Proper die design incorporates the safety needs of all operations. The size of the blocks selected for a die is dependent on the size of the hammer and on the type and number of impressions. Selection of too small a block increases the hazard of breakage and injury during forging. Danger of loosening or breaking of dies increases, if the striking surface is not held to a total area, which is in direct proportion to the size and stroke of the hammer in which it will be used. Narrow areas of striking surface should be avoided to reduce the possibility of cutting the metal which might overflow the gutter. Gutters should be adequate to completely contain the access metal, or flash and prevent it from being forced on to the striking surface where it can be squirted like bullets from the die.

Die Making and Die Sinking :

Probably the most important single factor for safety in die making is the establishment of definite uniform standards. These reduce operational hazards and avoid unusual or makeshift practices.

Die Making : Machine should be adequately guarded. Turntables are recommended for each bench for easier manually turning of the die blocks.

Die Handling : Hooks, eye or other devices for handling should not be attached to forging die as they break off under constant forging impact. Holes in opposite sides of a die block into which a pin is inserted for lifting with a sling is the desirable method. The pins should be of uniform size and sufficient length to provide slings with pins built into the sling assembly to prevent use of make shift pins in lifting blocks.

Die Storage : The storage of dies should provide a smooth and level base area with ample space between rows for mechanical handling equipment and easy access without undue die movement. Compartments for die storage racks should provide space for the largest and heaviest dies to be stored on the lower tiers and graduated with the smallest and lightest dies on the upper tiers.

Removal and Set up of Dies :

Key Driving : Extreme care should be taken when driving die key either in or out. Severe injuries as Well as strains and bruises can result from improper or careless handling. Correctly tapered key made of medium carbon steel, properly heat treated, should be used. Regular inspection for mushroom ends or other defects should be made both before driving and promptly after removal. Die key should be designed to protrude only a safe distance to permit driving from both front and back. When using a pneumatic key driver or suspended key ram, one man should direct operations. The immediate area should always be clear of both unused equipment and unnecessary personnel, because there must be sufficient clearance for necessary equipment and personnel for safe and efficient driving.

Dowels : Dowels should be properly designed and maintained. Dowels should be driven in tight mushroom head.

Die Repair : Die repairmen are subject to the hazards like burns from hot dies, danger of flying sparks, lacerations from die or tools, strains and bruises from improper handling of dies. To ensure safe operations, adequate space and equipment should be provided. Safety glasses and safety shoes must be worn at all times. Proper handling facilities should be installed. Repairing dies under a hammer should be discouraged.

6 COLD WORKING OF METALS

6.1 General:

There are thousands of metal working machines, machine tools and methods for variety of machine operations for general and special jobs which require individual guard design, treatment and different principles. The safety aspect of all such machines cannot be covered in one chapter. Therefore some common principles and methods of guarding are discussed below. An efficient engineering design and application are most

The five functional methods of cold working of metals are pressing or punching, shearing or cutting, rolling, bending and hammering.

1. Pressing or punching consists of forming, shaping, cutting or assembling metal by means of tools or dies attached to plungers or other moving parts. Various types of power presses, hydraulic presses and pneumatic presses are included here.

2. Shearing consists of cutting metal by the shearing action of movable knives. They may have straight or bevel edged blade. Shearing action may be of a guillotine knife, the sliding action of

scissors or the rolling action of rotating disks. Squaring shears, plate shears, guillotine shears, alligator shears, rotary shears, circular shears, *disc shears and rotary slitters are included here.

3. Rolling consists of forming or shaping, drawing or reducing the thickness of metal by bringing it in contact with revolving power driven rolls. Bending rolls, straightening rolls, corrugating rolls, heading rolls, flanging rolls, wire drawing and hot or cold rolling mills are included here.

4. Bending (braking) consists of bending or forming sheet metal by means of a tool or die usually actuated by a ram. Some brakes operate like press and some like a guillotine shear. Brakes are known as press brakes or apron brakes and are also identified by their operation e.g. folders, flanger, corrugators or crimpers.

5. Hammering consists of forming, shaping or breaking metal by means of gravity or power operated plungers which may or may not be fitted with a die, the metal to be formed resting on an anvil or a die. The plunger may be raised by mechanical, steam, hydraulic or pneumatic power.

The most dangerous part or zone is the point of operation and the purpose of point of operation guarding is to prevent injury to the operator at the part of the machine where above mentioned operations are carried out. Seven principles of such guarding are :

1. Design and construct tools so that the guards may not be needed.
2. Provide enclosures/covers and barricades.
3. Provide mechanical feeding device.
4. Provide device that prevents or interrupts the movement of tools when the operator is in the danger zone.
5. Provide remote control operating mechanism.
6. Provide device (guard) that removes the body part safely from the danger zone
7. Combination of these devices to achieve full protection.

For types and selection of guards see Part 4 of Chapter-14 on machine guarding. They indicate the principles of safe machine design. Individual motor drive, elimination of manual operation in hazardous zone, safe location, safe arrangement and position of machines and their dangerous parts, guarding of prime mover and transmission mechanism, ergonomic design and follow-up of statutory provisions and Indian standards are all useful to prevent machine accidents.

We saw that the point of operation is the dangerous zone which requires effective guarding. The best course is to provide fully automatic feeding and ejecting device at such point so that the man-machine contact is avoided. A hopper, magazine, feed roll or similar device should be designed and applied. If this is not possible, provide semiautomatic feeding device viz., a chute, slide, sliding die, dial or similar device which feeds to the point of operation. If this is also not possible, a manual feeding may be permitted with appropriate guarding and precaution. Automatic feeding and automatic ejection of the material will allow the danger zone to be fully enclosed (as the operator does not need to place his hands there) and full concentration on production (as no fear of injury), lhus increasing safety and productivity both.

6.2 Presses, Shears and other Machines:

6.2.1 Hand and Foot Operated Presses :

Non-power presses are generally hand or foot (kick) operated and are used for blanking, forming, punching etc., mostly on metal, but also on leather, card board plastics and pastry. An accident may take place if the operator's attention is distracted, the work is jammed in the die, the ram descends due to slackness in guides and insufficient frictional resistance, mistake of one operator if two operators work on the same press. Their safety devices include:

1. Closed tools, fixed guards and restricted stroke.
2. Interlock guards.
3. Pendulum and sweep away device.
4. Automatic device which arrests the ram.
5. Two hand control.
6. Firm foundation and mounting of the press.
7. Sufficient spacing or screens to prevent other workers coming into contact with moving parts.
8. The ram should not descend due to gravity.
9. Regular inspection and maintenance and
10. Good training and supervision.

6.2.2 Power Presses :

See Fig. 14.8 in Chapter 14.

For Schedule 6 u/r 54 of the GFR on Power Presses see Part 4.4 of Chapter-14.

Power presses are used in metal pressing, riveting, coining, assembling, staking, burnishing, trimming, sizing, flattening, bumping, embossing, homing, forcing, flanging, bending, straightening swaging, planishing, punching, extrusion etc. The power may be mechanical, hydraulic or pneumatic.

Types of Guards recommended for Power Presses are as under :

1. Starting and stopping mechanism to prevent over running of the press or descent of the ram during tool setting etc. A brake to stop ram in upper position and -an arrestor brake to arrest the movement of crank shaft and flywheel are also necessary.

2. Protection of tool and die by means of a fixed guard with a slip plate to enclose the front and sides of the tool, fixed guard surrounding the die with back tunnel for falling the pressed article to the rear, a feeding device through chute or otherwise at the bottom of the die guard, an efficient automatic or interlock guard in place of a fixed guard if the fixed guard is not possible

3. Fixed die-enclosure guard.

4. Fixed barrier guard to allow ready access to the die. The pivoting or sliding section must be interlocked with the press control to prevent operation of the machine when the section is open.

5. Adjustable barrier device attached to the frame of the press and which can be adjusted for dies of almost any size.

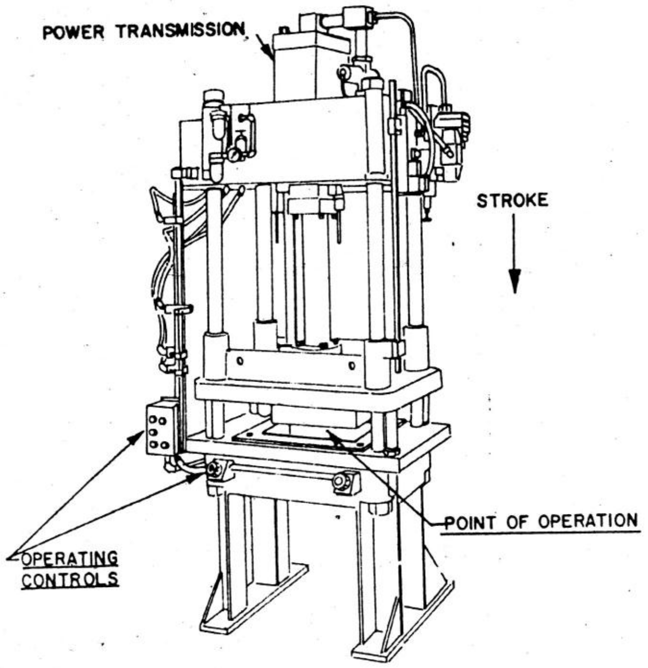
6. Gate or movable barrier device to enclose the point of operation before the clutch can be engaged.

7. Auxiliary point of operation device.
8. Two hand tripping device requiring constant pressure till the slide has reached the bottom of the downstroke.
9. Sweep device to push hands out of the point of operation zone. Such device is activated by the slide through linkage and may have a single or double arms.

10. Pull-back, pull-out or pull-away device to pull back hands as the slide descends. Such device should be adjusted to each job because of variation.
11. Electric or electronic device to prevent the pressure from cycling. Such device can be used only on presses having friction clutches with brakes to stop the press at any point of slide travel. It is not effective on punch presses with positive clutches because no device can prevent completion of the cycle once it starts.
12. Photo cell device operating on interruption of light beam near the dangerous zone.
13. Pedal guard over the foot pedal or switch button. A spring closed door requiring positive pressure in such guard provides further safety.
14. Instead of foot pedal, if the hand lever is used, a spring latch to prevent accidental or premature tripping, should be provided. If there are more than one operator, the hand lever should be interlocked.
15. A press with a positive clutch should have a single stroke attachment which disconnects the pedal or operating lever after each stroke.
16. When the press is used on continuous operation by making the single stroke or non repeat device inoperative, the die should be completely enclosed regardless of the method of feeding and ejecting device to avoid use of hands between die and punch. The six semiautomatic feeds are chute (gravity and follow), plunger, slide or push, sliding dies, dial and revolving dies. The best method of ejection is usually pick-up fingers or compressed air.
17. Hand feeding tools such as vacuum cup, tong, magnetic rod etc. to put and take small parts to and from a punch press.

6.2.3 Hydraulic and Pneumatic Presses:

The hazards are similar to those of the power presses. Some particular hazards are: sudden dropping of the slide due to power failure or breaking of a pressure line, defective dual controls, leaking valves, air pressure built up between dual controls in wiring etc.



Hydraulic press

Control measures are :

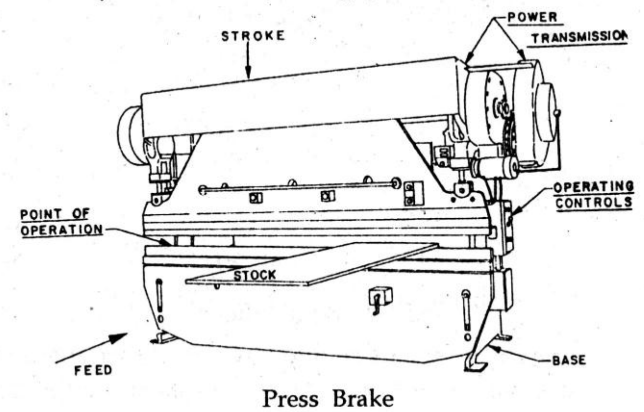
1. Limiting slide travel by means of a cylinder designed for short travel, by die or jig and fixture design or by auxiliary stops.

2. Fixed barrier guards.
3. Movable barrier guards.
4. Electrically controlled and air operated solenoid valve holds the slide in an up position in case of power failure.
5. Interlock guard to stop closing movement of the tools.
6. In case of Die-Casting Presses, to avoid trapping and splashes by molten metal, a sliding cover is interlocked with hydraulic or pneumatic power. A mechanical scotching device to restrain the platens from closing when the interlock sliding shield is open and guard operated electrical switches linked to the solenoid of the main platen cylinder control valve are also necessary.
7. Plastic Moulding Presses are of two types injection and compression. In case of injection moulding press, a sliding cover on vertical parting (dies) surfaces and in case of compression type an interlocked scotch (a heavy struck or a hook type) are necessary to avoid trapping between dies.
8. Rubber Moulding Press is compression moulding type and an interlocked guard is necessary to prevent trapping.
9. Bailing press needs a hinged guard interlocked with the driving power. .
10. Pie and Tart press used for moulding and filling pastry for pies and tarts, a hinged guard for protection against operating ram, electromechanical brakes on motor and blanking of gaps near tops of the moulds are necessary.
11. Brick and Tile presses need interlock guards or photoelectric safety device. In case of mechanically fed presses, a tunnel guard near delivery opening is necessary.

6.2.4 Press Brakes :

A Press brake is a type of power press used to cold-form angles, channels and curved shapes in plate, strip or sheet metal stock. It is also used for punching, embossing, corrugating, notching and other operation. Typical hazards are :

1. Crushing between the punch and the die or between the work being bent and the ram.
2. Cuts from contact with stock being processed.
3. Injuries from handling punches and dies.



Press Brake

Control devices are:

1. A front horizontal work rest cum distance .guard (this may be a fixed, automatic or interlocked guard) adjusted to coincide with height of die and supporting brackets and fall back device on rear side to stop the material being fallen.

2. Photo electric device in addition to fixed, interlock or automatic guards.

3. Worn punches and dies should be retooled or discarded as they give excessive strain on the press.

4. Instruction and training of operators.
5. Periodic inspection and well maintenance of parts in good working condition.

6. Starting devices such as two-hand switches or levers, treadle bars, foot switches. Foot controls should be covered by stirrup guards to prevent accidental tripping.

7. Reverse control with the start switch to use when tools become frozen.

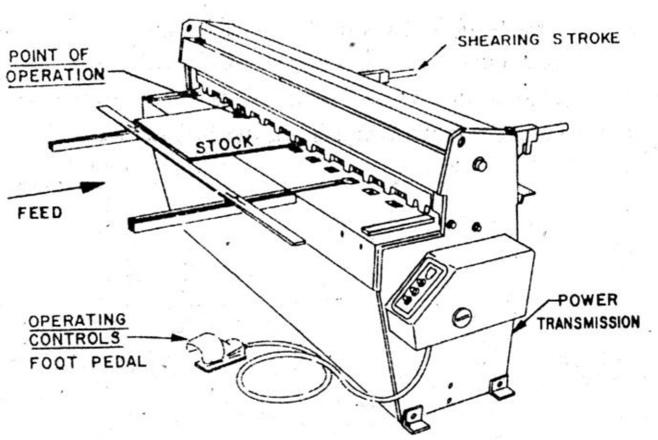
8. Soft metal pliers, rather than fingers, should be used to feed small parts to the press. Fingers should not be brought within 10 cm of the point of operation.

9. Positive over-run stop device, single stroke device and elimination of treadles by a shrouded pedal to prevent inadvertent operation.

10. Operators should be instructed to test operate the machine before start of each shift. They should be well trained and well informed of the work.

6.2.5 Metal Shears and Slitters:

For Shears, Slitters and Guillotine Machines under Schedule 6, rule 54, GFR, see Part 4.4 of Chapter-14.

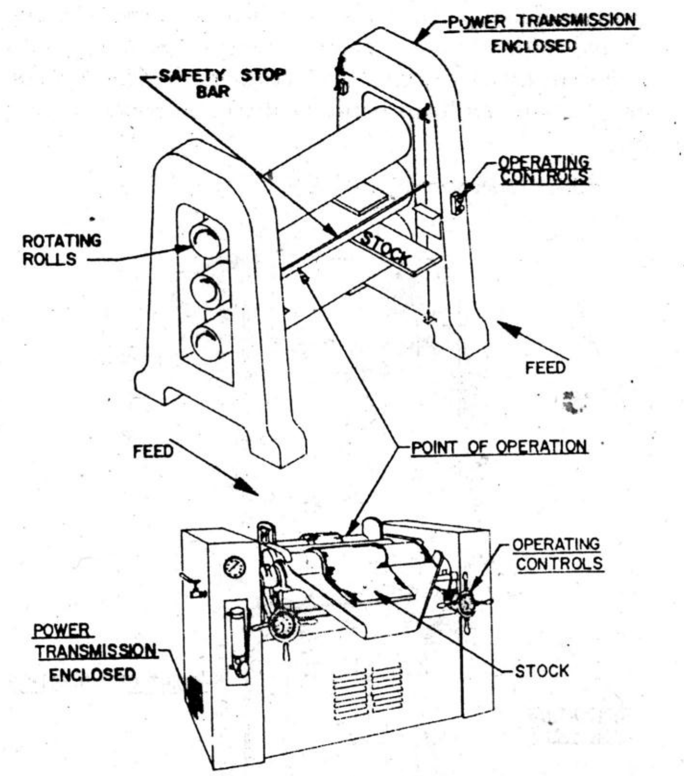


Sheet Metal Shear

Squaring shears should have fixed barrier guard placed at least 12 mm away from the shear (knife) and not more than 10 mm above the table or it may be a self adjusting barrier which will automatically adjust itself to the thickness to be cut with a limit of 8 mm above the table. The guard should extend across the full width of the table and it may be slotted, perforated or set at an angle to permit good visibility of the cutting line. The hold-down can be guarded separately or as a part of the knife guard. The back of the knife should also be guarded and chutes or slides should be attached to catch the work without reaching close to the knife. The entire length of the treadles should be provided with fixed guard allowing only a gap for the operator's foot. To avoid accidental tripping of the shear, an extra foot latch may be attached to the treadle.

Alligator shears are used in forging operations. For cutting rods and bar stock to length, the alligator shear operates continuously and the operator must be trained to time his movement with the opening and closing of the cutter. An adjustable guard should be set close to prevent the fingers from entering the danger zone.

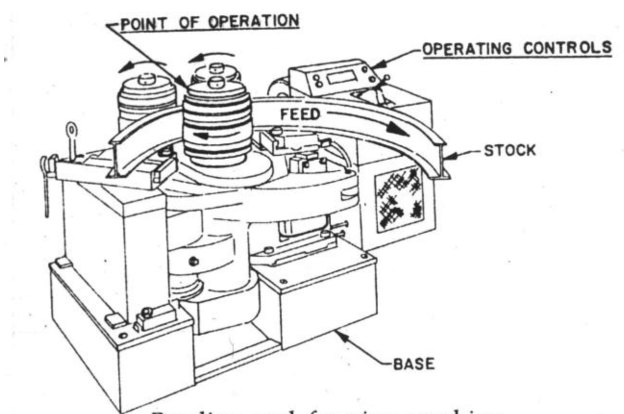
6.2.6 Forming Rolls:



Forming rolls and calenders

The nip point (full length) between the rolls should be guarded utilising a feed table. A special purpose feeding device (channel type) can be easily installed to feed short pieces. Reverse electric switches or emergency tripping bars are also useful. Brakes are necessary if the rolls continue to revolve after power has been cut off.

6.2.7 Bending and Forming Machine :

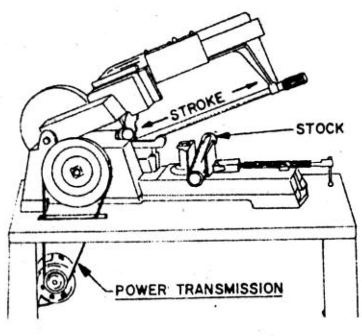


Bending and forming machine

This power driven machine is used to band preformed stock (ie. plate, bar, tube, pipe etc.) into desired shapes. Forming and banding are performed by dies, banding punches or other tools.

Hazards are - trapping in dies or in-running nips of rollers, sharp corners of materials, slipping due to lubricants and heating due to friction of motion etc.

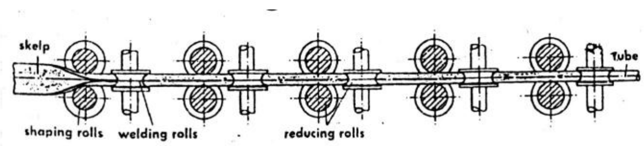
Point of operation should be guarded. Power transmission parts should be enclosed. Safety stop sweech is necessary and accidental restarting should be prevented.



6.2.8 Metal Cutting Machine :

Metal cutting machine has a blade (hacsaw) which works horizontally and cut the stock (bar, rod, plate, pipe, tube etc.). Coolant or lubricant is necessary. Hazards and control are similar to wood cutting machine. Guard is required to protect the moving blade and transmission machinery. See part 4.4 of Chapter 14.

6.3 Cold Rolling Mills :



Cold rolling for welded tube

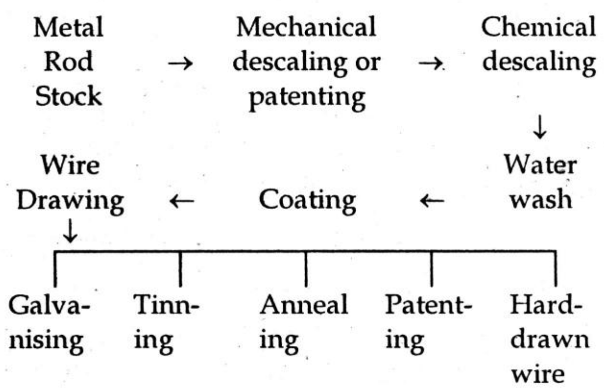
In Cold Rolling nip guards on rolls are necessary to avoid trapping. Dangerous parts of shearing, cropping, trimming and guillotine machines should be securely guarded. Oil spillage on floors should be cleaned. Gratings, absorbent materials and non-slip boots are necessary. Fire protection in plants containing hydraulic equipment is necessary. Accidents due to material handling should be avoided by methods stated in Chapter-15. Good housekeeping and good illumination are also essential. Hard hats, safety shoes, gaiters, gloves, goggles etc. should be worn.

Noise is at many places such as gearbox of rolls and straightening machines, pressure water pumps, shears and saws, throwing of metal products. Planning at design stage to segregate such noise zone is essential. Sound proof and heat radiation proof cabins for operators and crane drivers increase safety as well as efficiency. If technical control of noise is impossible or insufficient, ear protectors should be given to workers.

Vibration due to percussion tools and recoiling and rebounding effect of the material introduced into the gap between the rolls may cause health hazards for which engineering control is the only best remedy. Other measures are less effective.

6.4 Wire Drawing Operations :

The usual meaning of wire is a coiled metallic stock up to 3/8 inch cross sectional width. Wire drawing is cold working in which semi-finished metal rod stock is transformed into wire of smaller diameter and perfectly round cross-section by pulling it through a die or dies. The operational diagram is shown below.



Annealed or patented wire can further be subjected to acid clean, water wash, coating and redrawing. At the end the wires kept into wire stock or used for products. Drawn wire may be galvanised or tinned before delivery. During wire drawing operation either the wire is passed through dry lubricants (soap or sodium, calcium or aluminium stearates) or wet lubricants (soap solution, paraffin etc.) in which the dies are fully immersed for maximum lubrication and cooling which also gives a bright clean finish.

Hazards are acid splashes, burns, cuts, bruises, falling forging bodies in to eye, skin diseases due to acid, dusts, scale and lubricants and lead poisoning due to lead baths which are not covered or have no fume extraction.

Preventive Measures include guarding of dangerous moving parts, drive, nips, wire pulley nips and feed points by screens and barriers (adequate to contain a broken wire), enclosure of dangerous chemical processes, removal of fumes and dust by exhaust ventilation, use of personal protective equipment (safety helmets, goggles, face masks, gloves, aprons, footwear), safe material handling, training, barrier creams and medical examination of workers.

6.5 Machine Tools :

Classification, uses and safety aspects of machine tools are important.

6.5.1 Definition and Classification of Machine Tools:

A machine tool is a machine for making articles of a given shape, size and accuracy (according to the blueprints) by removing metal from work pieces. Machine tools are factory equipment for producing machines, instruments and tools of all kinds. Machine tools are classified as (1) Lathes (2) Drilling and boring machines (3) Grinding, Polishing or Finishing machines (4) Combination machine tools (5) Gear and Thread cutting machines (6) Milling machines (7) Planning, Shaping, Slotting and Broaching machines (8) Cutting off machines and (9) Miscellaneous machines.

CNC (Computer Numerical Control) machine tools are used for doing multi operations. CAD (computer aided design) and CAM (computer aided manufacturing) technique gives fully automatic machine tools operations.

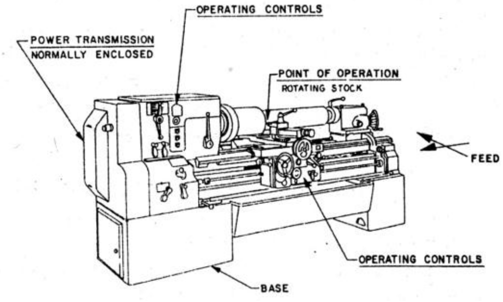
Machine tools may cause less serious accidents than do metal-forming machines, but, because of their greater use, their accidents may exceed in number.

6.5.2 Safety in Use of Machine Tools :

Machine-wise hazards and guards are explained below.

(1) Turning Machine (Lathe) :

Turning consists in shaping a rotating piece by revolving it against a cutting tool, thus producing a



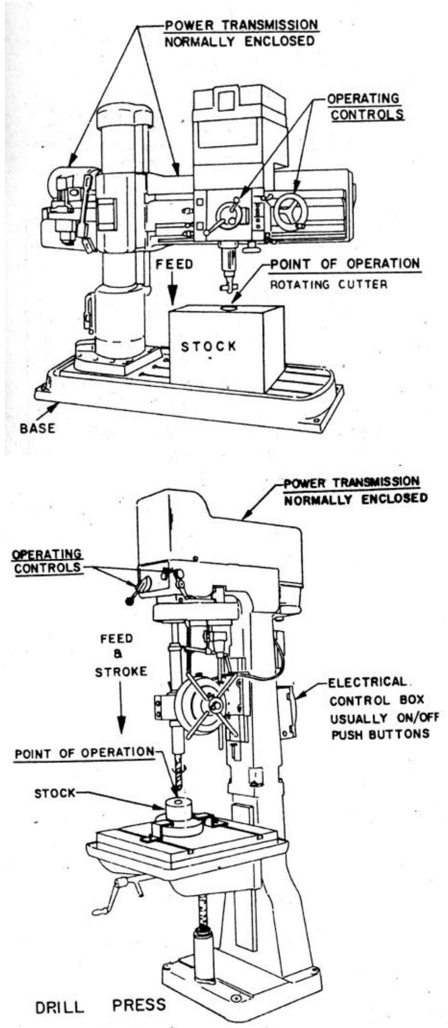
cylindrical surface. Machine tools coming under this category include all forms of metal-turning lathes including automatic screw machines. Some hazards and suitable guards are as follows :

S. No.	Hazards	Guards / Controls
1	Contact with projections of face plates and chucks.	Head-stock guard. Chuck guard.
2	Contact with projections of the dogs and projecting set screws.	Counter sunk screws.
3	Flying metal chips, long burrs and tunings.	Enclosure guard, portable perspex screen guard, use of chip breaker tool.
4	Hand braking of machines.	Foot pedal brake with trip switch, pneumatic chuck and feeding tools for small jobs.
5	Filling and emerying without a holding device.	Automatic emerying. Emery holder.
6	Gauging the job while machine is in motion.	Dial indicators. Tight fitting clothing.
7	Cleaning chips in motion	Safety hook / brush.
8	Projection of the work or stock beyond machine.	Tube guard. Bar stock guard.
9	Flying off the job.	Full enclosure guard.
10	Inserting blanks and removing die processed part without stopping.	Spindle jaws, mechanical feeding device and safe fixture.
11	Splashing of coolant resulting in slipping hazards and dermatitis.	Splash guard, pan and enclosure guard mounted on rollers. Floor mats.
12	Flying chips of cast iron, brass and other non ferrous metals.	Chip guard. Goggles or face shield.
13	Pulleys, belts, ears, setscrews.	Fixed guards Hinged guard.
Turrets & Capstan Lathes :		
14	Counter weight falling and bar flying through turret head.	Tube guard. Blank off hole.
Multispindle Lathe :		
15	Collecting component while just martin off.	Wire mesh. Spoon collectors.

16	Parted component comes in between tool and the first spindle.	Sharpening tools properly

(2) Boring or Drilling Machines :

Boring or drilling consists of cutting a round hole by means of a rotating cutting tool. Machines ir this class are vertical or horizontal, fixed or portable drills, reamers, honors. Some hazards and guards are as follows :



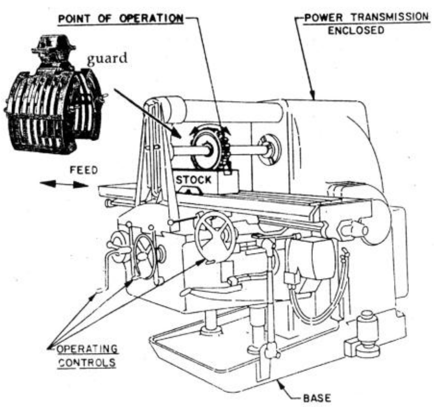
Vertical boring machine

S. No.	Hazards	Guards / Controls
1.	Spindle contact.	Sleeve guard.
2	Tool and chuck.	Telescopic drill guard, combined drill & check guard.
3	Unclamped job and breakage of tool or struck by the job.	Clamp the job. Use iron plate (L section) for a big job.
4	Hair and loose clothing in contact with revolving spindle and bit.	Cage type guard. Cap. Tight fitting clothing. Gloves neckties long sleeves not permissible.
5	Sweeping chips by hand.	Brush.
6	Belts, pulley, gears, setscrew.	Fixed guards
7	Flying particles	Barrier guard, Goggles.

8	Rotating horizontal table.	Surrounding machine guard.

(3) Milling Machines:

Milling consists of machining a piece of metal by bringing it into contact with a rotating cutter with multiple cutting edges. Machines in this class are vertical or horizontal milling machines, planer-type milling machines, gear hobbers and special machines using one or more milling cutters with other tools. According to one survey @ 66% of all milling machine accidents occur when operators load, unload or make adjustments while machine in motion. Some hazards and guards are as follows :

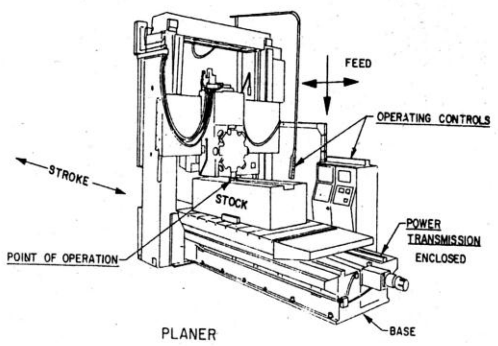


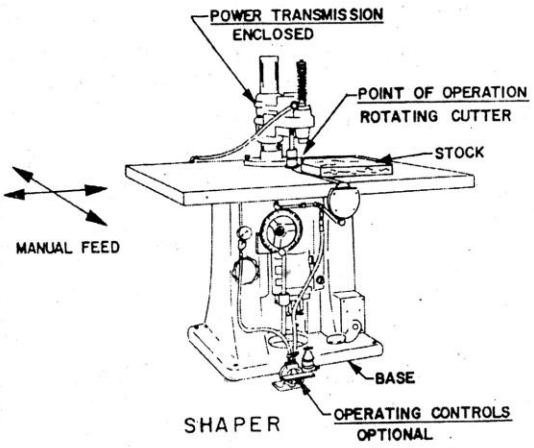
Horizantal milling machine

Sr. No.	Hazards	Guards / Controls
1.	Revolving cutter	Jaw type interlocked or adjustable guard, or a self closing guard which automatically close when the job tables moves backward and opens when it moves forward for operation. The guard may be transparent if visibility is required.
2.	Removing chips and swarf cleaning by hand and using rag to clean oil while it is running.	Brush, magnetic sweep, cleaning after stopping the machine. Long sleeves to be avoided.
3.	Failure to clamp the work properly.	Permanent magnetic plate fitted on the bed.
4	Failure to draw the job back to a safe distance while loading or unloading.	Fixed guard.
5	Tightening or loosening arbor nut and other parts.	Use proper spanners. Education and training.
6.	Power drive pulley, belts, gears etc.	Closed housing or fixed guard and start / stops switch within reach.

(4) Planning & Shaping Machines :

Planning consists of machining a surface by moving the work (job on bed) back and forth under a stationary cutting tool. In shaping the work is held stationary under a reciprocating tool. Machines in this class include planers, shapers, broachers, slotters and key seaters.

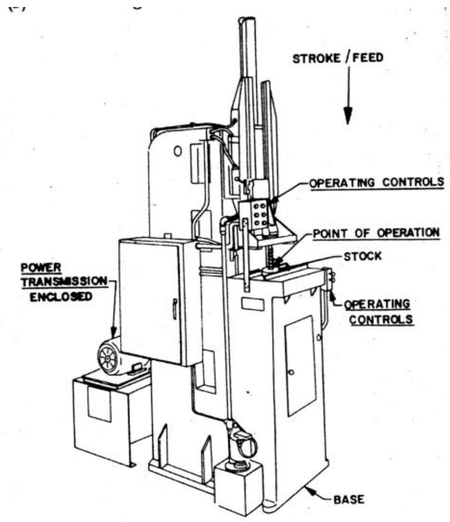




Some hazards and guards are as follows:

Sr. No.	Hazards	Guards / Controls
Planners :		
1.	Bed traveling within short distance from fixed object.	Fixed guard or fencing to prevent entrapping within 45 cm (section 25, F.A.) All gaps to be guarded.
2.	Falling material from the table or bed.	Fixed or self adjusting table guards on sides. Job clamping device.
3.	Pulley, belts, drives and reversing dogs.	Fixed guards, starting and stopping device.
4.	Flying particles.	Aprons, goggles side runway for large planners.
Shapers :		
1	Speed changing and other drives	Fixed or hinged guards.
2.	Flying and removing chips.	Aprons, goggles, brush.
3.	Flying jobs.	Clamping device.
4.	Moving ram and tool	Transparent shield for tool. A retriever to the limit of the stroke of ram channel.
5.	Reversing dogs.	Fixed guard.
6.	Other as for planners.	As for planners and stated above.

(5) Broaching Machine

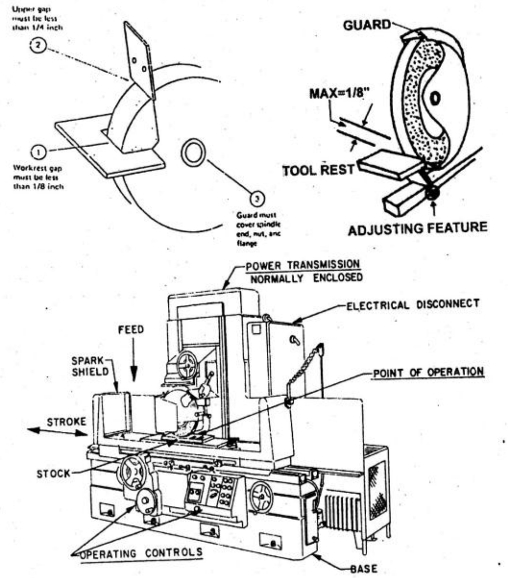


Broaching machine

(6) Slotting Machine

Slotting machine is like a shapping machine Tool may work vertically or horizontally. Hazards and controls are similar to that of shapping machine. Se(part 6.5.2 (4).

(7) Grinding Machines:



Surface grinder

Grinding consists of shaping metal by bringing it into contact with a rotating abrasive wheel. Grinding may be internal or external, flat, cylindrical or centerless. Polishing, Buffing, honing and lapping are also considered as parts of the grinding process.

Main causes of accidents are wheel breakage due to hidden or undetected cracks, mechanical shock, over or loose tightening, unchecked traverse of the work on to the side of the wheel, over speeding, incorrect selection of wheel, excessive heating, excessive work pressure and eye or face injury due to flying particles.

Some hazards and guards are as follows :

Sr. No.	Hazards	Guards / Controls
1.	Flying particles, Coolant and lubricants.	Goggles or face shields. Eye shield attached with the machine frame.
2.	Dust generation.	Local exhaust ventilation.
3.	Bursting of the wheel.	Protection hood (wheel guard) and protection of flanges. Chucks or bands. No over speeding. Avoid grinding on the side of the wheel. Compliance of sec. 30, Factories Act.
4	Accidental contact with the running wheel.	Tool or work rest and its proper adjustment to avoid contact and trapping.
5	Portable grinders.	Wheel guard. Electrically earthed and fully safe. Shock-proof gloves.
6	Belt drive and other dangerous parts.	Fixed guard

Main precautionary measures are as under:

1. Selection of a right wheel for right speed and right diameter. With the same rpm, peripheral speed increases as wheel diameter increases and centrifugal force increases as peripheral speed increases. Due to excessive centrifugal force, the wheel may break. Therefore peripheral speed (m/ s or f/m) is most important and a grinding wheel should be selected based on its peripheral speed.

2. Ring test is carried out by a qualified person to check any crack in the wheel.
3. Speed test before installing wheel. Test speed should be 1.5 x service speed. Testing should be on special stands.
4. The wheel should never be rotated at a higher speed than that stamped on it.
5. Wheel guard (hood) should be fastened securely to the grinding head to protect against flying fragments or coolant if any. An adjustable tongue or a movable wheel guard is necessary to restrict wheel exposure to 6 mm.
6. Abrasive dust and slurry removal equipment should be in good repair. Dust generating equipment should be in a separate room.
7. Electrical earthing, bonding and on-off switch in easy reach.
8. Proper storing in dry area . Use special racks, shelves or boxes according to the shape & size.
9. Proper dressing of the wheel.
10. Use wheel washer and flanges of correct size and equal diameter (at least 1/3 dia of the wheel).
11. Avoid overtightening or loose tightening. Use proper tool. Proper mounting to avoid internal stresses. Use mounting blotters supplied with wheels.
12. Check spindle threads so that the nut is not loosened on revolution.
13. Use spindle of correct diameter.
14. Balance the wheel to avoid vibration. Balance before installation.
15. Apply the work slowly and gently. Do regular lubrication.
16. Avoid side grinding, over speed and cleaning, adjusting or gauging while the machine is in motion.
17. Wheel exceeding dia 15 cm or speed 50 m/s should have a strength-test mark.
18. Adjust tool rest properly.

A checklist of the following type should be used by a grinder or maintenance man.

Checklist for a Grinding Machine

Name of the m/c : Identification No. Location& Department: Type & Use: Size _________________ RPM _________________ Peripheral Speed _________________

Item	**Tick if ok**
Wheel guard :	
Securely fastened	☐
Properly aligned	☐
Tongue adjusted (to minimize guard clearance)	☐
Tool rest :	
Within 3mm of the wheel	☐
Properly tightened	☐
Speed :	
Legal notice displayed	☐
Wheel selection correct	☐
Drive guard :	
Pulley-belt guarded	☐
On-off switch :	
Properly working	☐
Within easy reach	☐
Flanges :	
Equal size	☐
Correct dia (1/2 wheel dia)	☐
Wheel face :	
Dressed evenly	☐
Well lighted	☐
Frame & Foundation :	
Securely mounted	☐
No vibration	☐
Goggles / Face Shield :	
Clean	☐
In place	☐
Unscored	☐

(8) CNC Machine :

Numerical Control of a machine tool means automatic control of its operation under a programme expressed in numbers or symbols which determine values and kinds of displacement of operative members of the machine. Such machine tools are known as NC machine tools. When their control is computerised, they are known as Computerised Numerical Control (CNC) machine tools.

The change-over from job to job in NC machine takes less time than other type of automatic machine where this is done by changing cams or templates, displacing stops, limit switches etc. Such automatic machines are also programme-controlled, but their setting up is complicated. They are advantageous only in mass and batch production.

The main feature and advantage of NC machine tool is the simplicity of changing over, which makes it possible to develop economically effective systems of automation for small-batch and single piece production. Programme can be fed directly in the machine for limited volume, or it can be prepared outside the machine for unlimited volume. In the second method, information is stored in the storage medium like punched tapes, magnetic tapes, wire discs, or drums, paper tapes, punched cards, films, and in the movement of storage medium, this information is successively read out and is employed to control the movements of the machine operative members. The storage medium is usually prepared outside the machine by applying computing technology (computers) and special devices for recording the programme. CNC system can be employed for lathes, milling machines, drilling, boring and other machines with automatic tool changers which make it possible to increase output, reduce rejects and inspection operations.

The decimal system or binary system of noting numbers is used to represent machine part movement. The displacements are specified in pulse systems with the number of pulses coded. The information can be recorded, for instance, in the form of holes on a punched tape. In computer system, electronic media is used to give number, code, symbol and graphic to store and translate information for automatic machine movement.

The basic components of CNC system are :

1. CNC (computer numerical control)
   It contains
   a. CPU (central processing unit)
   b. PLC (programmable logic control)
   c. Inputs/outputs
   d. Memory
2. Axis and spindle control
   It contains
   a. Servomotor for axis
   b. Power motor for spindle
   c. feedback for drives
3. Positioning display system
   It contains
   a. Position sensors
   b. Processing of sensors
   c. Display unit

The function of the CNC system is to take the commands in the form of a program or by manual data entry and to give command to the motors to achieve the required position movement. It also stores the programs, controls the logic functions of the machine and checks all inputs/outputs. To take care of the functions it has following components :

Safety & Maintenance :

Many tools are fitted in an auto tool changer which operates suddenly as per the programme. Therefore all moving mechanism of a CNC machine should be totally enclosed in a plastic cover to afford safety and visibility. Such covers should be so interlocked that inner parts will not start till the cover is closed and will not open till the inner parts are stopped. Limited openings for the job insertion, machined part ejection and scrap removal are permitted. Any manual control, if required, should be remote. Machine should not start inadvertently. Necessary trips and locks are provided for built-in safety. Electrical double earthing, start-stop switches in easy reach, sound foundation to eliminate vibration, automatic lubrication system, mono-rail and chain pulley block to handle heavy machine part or the job, numerical display system, sufficient surrounding space for work and maintenance and protection of computer system are basic safety requirements. Tool magazine operating at a height as in case of steel plant, are considered safe by position. Machine operators should be qualified and well trained for the operation of machine and the job.

6.6 Selection and Care of Cutting Tools:

Cutting tools are fitted to machine tools for required operations on the job.

Selection of a right machine and right cutting tool for the job is essential. From a variety of lathes single or multi operation, turret, spinning, screwing etc. - a particular one is to be selected depending on the type of operation to be carried out.

Similarly selection of a drill for small holes, boring machine for big holes, planning machine for a big sized and heavy job, slotting or shaping machine for small jobs, metal saw (circular) or gear cutter milling machine for specific work, internal, external or centreless grinding machine and selection of buffing or polishing machine need special knowledge and experience.

Cutting tools should be stored and used carefully. Their sharp edge is to be protected to avoid injuries and sharpened for easy cutting. A tool rack should be provided for classification, easy placement and preservation. Tools store area should be dry and protected from raining, fumes, gases and other chemical effects. It should be well ventilated and lighted. Proper stools or ladders should be provided to prevent fall of tools while putting or taking from the racks. Passageways should be more than a meter wide.

While fitting the cutting tool to a machine, necessary hand tool or equipment should be used. Chucks and fixtures should be properly positioned and tightened. Alignment of tool centre is important. Tool guard is necessary to prevent injury in case of its breakage. Cutting tools should be regularly inspected for defects, dressed for proper cutting angle and sharpness of the edge. Broken and unsate tools should not be used. Tool and tip metal should be properly selected.

6.7 Safe Operations and Maintenance of Machines:

See Chapter-14 for general principles of machine guarding. They are equally applicable to cold working of metals including machine tools. Some instructions for safe operation and maintenance are as under :

6.7.1 Safe Operation of Machines :

1. Operators should be well trained for machine operation.
2. Trained supervision should be provided.
3. Safe work procedures should be followed to avoid short-cuts and chance taking.
4. Dangerous parts must be properly guarded.
5. New machine, equipment or tool should be inspected before use.
6. Running machine should not be left unattended. It should be shut down in a safe mode. Off switch should have locking device. Machine under repair should have tagging and warning notice.
7. Operators should not wear loose-fitting clothing, loose sleeves, neckties and metal jewellery. They should not lean over rotating parts.
8. Operators should wear eye and head protection. They should run the machine at proper speed.
9. Gagging, callipering and manual adjustment should not be carried out while machine in motion.
10. Open hands should not be used to clean scraps and chips. Brushes, vacuum cleaner or special equipment should be used for that purpose.
11. Proper hand tool should be used and job should be properly fitted in the machine. Constant watch for proper machining is necessary.
12. Compressed air should not be used to blow chips from machine or clothing. If it is to be used, nozzle air pressure should be less than 20 psig.

13. Planned maintenance system (PMS) includes post inspection repairs, routine servicing and overhauling, periodical inspections and scheduled repairs. A widely used PMS cycle is GIRIRIMIRIRIMIRIRIG where G, I, R & M indicate general overhaul, inspection, routine repairs and medium repairs.

6.7.2 Total Productive Maintenance (TPM) :

It is a philosophy which brings results when practiced. Motivates people to come together, builds team sprit with pride of ownership. A person strategy for achieving excellence in business through complete cultural age.".

Dr. Doming gave birth to concept of TQM in 1970 after World War II, which had a great influence on Japanese Industry. TPM is evolved from TQM.

It becomes popular in manufacturing industries.

TPM was brought to India in 90's and successfully implemented in many industries.

Objectives:

1. To maximize Overall Equipment Effectiveness through total employee involvement.
2. To improve the Equipment Reliability and Maintainability &: this will improve Quality & Productivity.
3. To cultivate the equipment related expertise among operating personnel.
4. To create anenthusiastic & lively work Environment and culture.

Benefits:

TPM encompasses a powerful Structured Approach to change mind set amongst people marking a visible change in the Work Culture of the Company.

1. Zero Defects.
2. Zero Breakdowns.
3. Zero Customers Complaints and,
4. Zero Accident.

Purpose of TPM:

It involves everyone from top to bottom to make the Organization Efficient & Effective with

1. Lowest Cost.
2. Zero Waste, and
3. Excellent Quality with,
4. Zero Accidents.

It guarantees improved results, visibly transforms the work place, and raises the level of knowledge and skills of the employees.

TPM Parameters:

Effectiveness of TPM in industry is reflected by improvement in following parameters:

P - Productivity of Enhancement.
Q - Quality Improvement.
C - Cost Control.
D - Delivery in time.
S - Safety.

M - Morale.

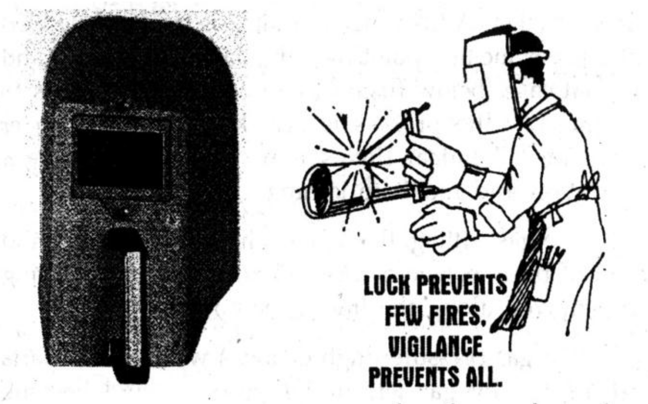
Pillars of TPM are -

1. Autonomous Maintenance (Jishu-Hozen)
2. Focused Maintenance (Kobestu-Kaizen).
3. Planned Maintenance. .
4. Quality Maintenance.
5. Development Maintenance.
6. TPM in administrative & support departments.
7. Education and training.
8. Safety and environment Management.

7 SAFETY IN OTHER PERATIONS

7.1 Welding and Cutting Operations :

Welding and cutting operations are frequently used in construction, demolition, repair and maintenance works. The equipment may be permanently installed or portable. Hazards of permanent installation .can be minimised by safe design and therefore a fixed welding shop is more desirable than portable moving welding work. Where the work pieces are very heavy or not movable or at height or depth etc. portable equipment is the only convenient device.



Welding is a process to unite pieces of metal at joint faces by heat or pressure or both and sometimes use a filler material. Cutting is a process to remove the metal by the chemical reaction of the metal at high temperature. In both these operations, the common factor is high heat energy and high temperature for melting or fusing of metals.

The three common sources of heat are :

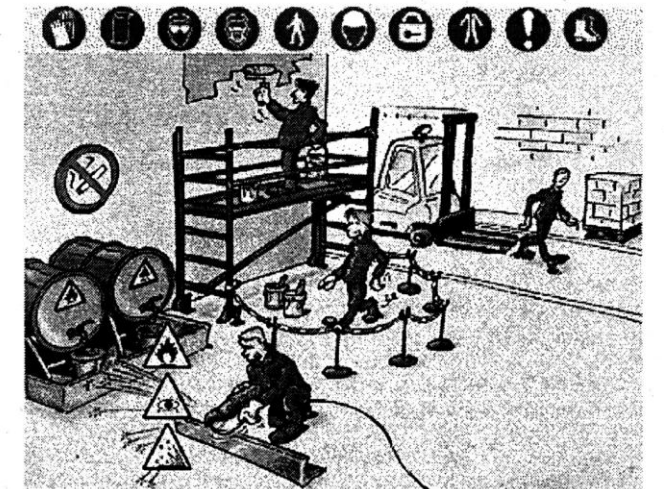
1. Flame produced by combustion of flue gas with air or oxygen (Gas Welding)
2. Electric arc, struck between an electrode and a work piece or between two electrodes (Electric or Arc Welding)
3. Electrical resistance offered to passage of current between two or more work pieces (Resistance welding including spot, steam, projection and butt welding).

Other processes are atomic hydrogen welding, electron beam welding, electro slag welding, flash welding, friction welding, laser welding and drilling, metal spraying, plasma arc welding, plasma arc spraying, tungsten arc cutting, spark erosion machining, stud welding and thermit welding.

7.1.1 Welding and Fire Safety :

Nearly six percent of all industrial fires are started because of unsupervised welding repair jobs without a permit-to-work system.

Common Causes of Fires in Welding and Cutting



Fire originates from a heat source and feeds of combustible materials. Welding operations produce sparks which can travel long distances, particularly if the welding torch is not adjusted properly. The hot slag of burning metals may drop down as globules which retain their heat for a very long period and can start a fire long after the welding job is completed. Similarly, application of heat during welding to a closed vessel, pipe or tank can result in an explosion if the vessel contains flammable liquids or gases. An empty vessel that had contained a flammable material is more dangerous than one fully filled with flammable material, because it may be full of invisible vapours.

Electric arc welding involves passage of very large quantities of current, often running into hundreds of amperes. The passage of electric current itself creates heat and therefore cables, junctions, switches and other electrical appliances must be of adequate current carrying/breaking capacity.

Precautions for Preventing Welding Fires:

(A) Before Welding-

1. Work Permit: Make a thorough inspection of the workplace. Ensure that it is safe for welding operations. Issue a written permit as shown below for commencement of welding work, especially when contract workers are involved.

Permit for Cutting and Welding with Portable Gas or ARC Equipment

Date ____

Building ____

Department ___________________________________ Date __________

Place or Location ____

Work to be done ____

Special Precautions ____

Is fire watch required?

The location where this work is to be done has been examined, necessary precautions taken, and permission is granted for this work.

Permit expire ____

Signed_____________
(Individual responsible for authorising welding and cutting)

Time started _______________ Completed _____________

2. Check if the area contains flammable liquid/ gases. Ensure that there are no floor openings, open windows nearby or any such ready access through which sparks can pass and fall on combustible materials. (In one such case, flammable vapours on the ground floor 7 mt below, were ignited due to a welding spark fallen from that height and the welder died due to burn injury).

3. Examine whether the job can be welded outside the premises and brought back.

4. If not, remove all combustible materials to a safe distance of at least 20 feet.

5. Sweep the floor and the area nearby and remove all waste materials.

6. If any of the combustible materials cannot be removed, cover it with non-combustible coverings like metal sheets or asbestos curtains.

7. If the floor itself is combustible, cover it likewise and wet it before starting welding work.

8. In case welding or cutting has to be done on a vessel, pipe or other container which contains or had earlier contained flammable liquids, ensure that a detailed 'permit-to-work' procedure involving isolation, blanking, purging, inerting methods is followed. Consult the Indian Standard 3016 for additional details.

(B) During Welding

1. Use portable screens, booths or partitions to minimise the spread of sparks.
2. Keep an observer ready with a portable extinguisher (dry powder), water buckets etc.
3. Ensure that gas cylinders, hose pipes, torches and other appliances are properly selected, installed and used.
4. In case of electric welding, check the connections, cables and earthing in particular.
5. Ensure that the welder uses appropriate personal protective equipment like goggles, gloves, boots, spats and if necessary an approved respirator.
6. Do not leave electric circuits on, or blow-torches burning when the welder has to take a tea break or has to be away for any reason.

(C) After Welding

1. Inspect the area for sparks or smouldering materials. If you find any, remove and extinguish them.
2. If any portable extinguisher has been used, replenish it.
3. Gas cylinders, blow-torches etc. should be returned to the stores or kept at the authorised place.

7.1.2 Gas Welding and Cutting :

In gas welding, oxygen or air and a fuel gas (acetylene, hydrogen, LPG or propane, butane, coal gas, natural gas or their combination) are fed to a blow pipe (torch), usually hand held in which they are mixed prior to combustion at the nozzle. The heat melts the metal faces of the parts to be joined causing them to flow together. A filler metal or alloy is frequently added at a lower melting point than the parts to be joined and in that case (below fusion temperature of the parts to be joined) the process is also known as brazing or soldering. Chemical fluxes may be used to prevent oxidation and facilitate joining.

In gas cutting, the metal is heated by a flame and a jet of pure oxygen is directed on the point of cutting and moved along the line to be cut.

In gas pressure (high or low) welding, the parts are heated by gas jets under pressure, and become forged together.

Safety in handling Cylinders :

1. Do not tamper with the numbers or marks stamped on the cylinders.
2. Do not drop cylinders or let them strike violently.
3. Do not lift cylinders with an electro-magnet. In case cylinders are to be lifted by lifting device, they are to be slung in suitable cradles or platforms. Do not use slings.
4. Do not tamper with the safety device in the valves or cylinders.
5. Do not use oil or grease as lubricants on valves or attachments.
6. In case the regulator or cylinder valves have frozen, wash with hot water, never by a flame.
7. Never transport cylinders with regulator and hose attached unless a proper trolley or carrier is used. While transporting, the cylinder valves should be shut.
8. Do not drag cylinders. They may be rolled on the bottom edge.
9. When the cylinder is not in use, keep the metal cap in place to protect the valve.
10. Before returning empty cylinders, mark them EMPTY
11. Always consider cylinders full, if not definitely known.
12. When in doubt about the proper handling, consult supplier.

Safety in Storage of Cylinders :

1. Ensure that the cylinders are stored properly. Store rooms should be dry, well ventilated and away from oil, or other flammable substances.
2. Store empty and full cylinders separately.
3. Store room should be fire proof and the lighting or electrical switches should of flame- proof type.
4. Oxygen cylinders should be stored away from the cylinders containing combustible gases, preferably in separate rooms. If stored in the same room, they should be kept far apart (6m) or have a non-combustible barrier in between of at last 2 mt height.
5. Acetylene cylinders should always be stored upright.
6. Cylinders are not designed for temperatures in excess of 55 ° C (130 ° F). Accordingly, they should not be stored near the sources of heat, such as radiators, furnaces, etc.
7. Cylinders stored in the open should be protected from the effects of sun and rain to prevent corrosion.
8. Cylinders should be stored away from elevators, stairs, or other such places where they can be knocked down or damaged by passing or falling object.

The Gas Cylinder Rules and following IS should be followed.

IS:818 Code of practice for safety and health requirement in electric and gas welding and cutting operations.

IS: 1179 Equipment for eye and face protection during welding.
IS: 3016 Fire precautions in welding.
UK HMSO Booklet Welding and Flame-cutting using compressed gases.

Safety in Regulators and Hose connections:

Regulators or reducing valves are used on both oxygen and fuel gas cylinders to maintain gas supply to the torches at correct pressure. Care has to be taken to see that the regulator chosen is the correct one for the gas contained in the cylinder. In order to prevent attachment of oxygen regulators to the fuel gas cylinders or vice-versa, the connection for oxygen cylinders are made with right hand threads and those for acetylene cylinder with left hand threads. A regulator is a delicate instrument and has to be handled carefully and not dropped. Leaky regulators should be withdrawn from service immediately.

Oxygen and fuel gas hoses should be of different colour or otherwise identified and distinguished from each other for proper connection on the torches. Red is generally recognised for fuel gas and green or black. hose is used for oxygen. One type of gas regulator should not be used for another type of gas.

Safety in using torches :

1. Set the regulators to the recommended working pressure.
2. Keep the blow pipe nozzle away from any source of ignition until the fuel gas is flowing 'freely from the nozzles.
3. A spark lighter is recommended for lighting purposes.
4. Clean the torch at regular intervals.

Sometimes a protective system is provided in the fuel gas piping to prevent -

- Back flow of oxygen into the fuel gas supply system
- Passage of a flash back into the fuel gas supply system
- Excessive back pressure of oxygen in the fuel gas supply system. Such system (back pressure valve, non return valve) must be checked for its effective working.

7.1.3 Schedule-24, Rule 102, Gujarat Factories Rules, 1963 :

Welding/Cutting Operation with the use of LPG/ Acetylene/Argon:

Safety measures prescribed in this Schedule are:

1. Gas cylinders, filled or empty, shall not be stored in a room where welding or cutting work is to be carried out.
2. Cylinder in use shall be kept in vertical position and tied to prevent its fall.
3. Source of ignition including smoking is prohibited near flammable gas cylinder except which is in use.
4. Cylinders shall be stored at more than 10 m from source of ignition or excessive heat.
5. Standard pressure regular and second non-return valve to prevent back flow shall be used.
6. Standard torch with non-return valve shall be used.
7. Suitable fire extinguishers shall be kept ready near welding/cutting place and gas cylinder storage.
8. Pipe lines shall be colour painted for identification of each gas.
9. Welding/cutting is prohibited in explosive atmosphere.
10. Welding/cutting zone shall be cordoned by screens of 7 ft (2.15 m) height where persons other than welders and their helpers are working or passing.

11. All welding/cutting equipment shall be examined by a competent person in a period of 15 days.
12. Welding/cutting work shall be carried out by specially trained workers.
13. A log book of examination of equipment and a register of trained workers shall be maintained in the forms directed by the Inspectors.

7.1.4 Arc Welding (Electric Welding) :

In this process, an arc is struck between an electrode and the work pieces, which are connected to an AC or DC supply. In this usual process, the welder 'strikes an arc' by touching his electrode to the work piece and causes a "short-circuit" stripping electrons from gases in the surrounding air, ionising it and producing the arc. A temperature of about 4000°C is obtained and the work pieces fuse together. In this type of welding, new metal is fused, either by melting the electrode or by melting a filler rod which does not carry any current. Sometimes some inert gas or a solid flux is also used to shield the weld from oxidation. The operations also include chipping of slag, etc. from the weld.

The current used for electric arc welding may be direct or alternating but the voltage has to be low and consistent. The voltage of 100 between electrode and work should not exceed for hand welding. The supply of current for electric welding would require a generator or transformer of suitable voltage. The commercial 'main supply' (230V) is not suitable on account of the voltage and also it may not be permissible to earth the circuit at points other than approved by the supply authority. Any transformer used for giving supply of current for welding should be double wound to ensure complete isolation of welding circuit from the main supply. The current used, with small diameter electrode on thin sheets for manual arc welding varies I between 10-50 Amps. With larger diameter electrodes, the current used is more. For manual welding, the welder should be able to withstand the heat and as such the current value should not exceed 500-600 Amps.

Hazards : The operations of welding and cutting are carried out at high temperatures which are source of "Fire" or Explosion. The liberation of the heat and energy into the work place can cause chemical and physical reactions which do not normally take place at room temperature. The reactions include the various types of radiation and release of various toxic gases, vapours, fumes, etc., which may affect the health of the workers engaged in the process and near by. Some hazards are :

1. Flying metallic sparks and molten metal. Some of these sparks consist of tiny shreds of extremely hot metal, sometimes molten, which may be hotter than 1000° F and may cause painful burns on exposed skin. These sparks are also source of fire or explosion hazard, in case flammable materials are near by.
2. Hot surfaces of the work pieces after welding or cutting may cause harms to unsuspecting persons.
3. Flying materials while chipping the weld.
4. Enrichment of Oxygen (due to leakage from Oxygen cylinder) radically changes flammability.
5. Glare which comes when the arc is struck or the torch is lit. It affects the optic nerve at the back of the eye. Special eye glass (screen) is required.
6. Thermal heat radiation from welding can cause headache, fatigue and eye damage.
7. Infra red radiation. Some of the IR is stopped by the upper layer of the skin but part of the radiation penetrates the exposed skin and may cause serious skin burns or pigmentation. Since eye has no absorbing layer, it can be severely damaged by this and may cause "heat cataract".
8. Ultra-violet radiation may cause skin burns and prolonged exposure may lead to skin tumours. Inert gas shielding is a strong source of UV radiation.
9. Workers on the shop floors may be exposed to noise due to welding, cutting or chipping operations.
10. Fall of materials and equipments during operation.

Electrodes and Holders : Electrode holders are used to connect the electrode to the welding cable supplying secondary current. In order to prevent accidental striking of an arc they should be fully insulated. Holders should be capable of handling the maximum current required by the electrode. Electrode holders are liable to become hot during welding operations if they are not designed for the purpose, i.e. holders for light jobs are used for heavy work or if there is a loose connection. In case the correct size of holder is not available an additional holder should be provided so that one can cool while the other is in use. Dipping of hot electrode holders in water should be prohibited as it may expose the worker to electric shock.

Electric Shock : The work set up is such that the work is grounded and if the worker is not careful, he can receive electric shock. A welder may be exposed to the open circuit voltage while changing electrodes, setting up work, or changing working position. Danger is more in humid environment or if the welder is "sweaty". The risk of shock can be reduced by providing an insulating barrier between the worker and the ground of nearby metal objects, while changing electrodes. Dry leather gloves act as good insulator. It is also advisable to use shoes with rubber soles. The electrode holder should be sufficiently insulated between the handle and the bare part that grips the electrode. The welding cables should be of good quality to resist hard wear and inspected for insulation defects. Joints between cables should be by insulated connectors of equivalent capacity. The welding equipment must be safely earthed. There should be two distinct and different earthing circuits so that, in case if one fails, the other will afford protection.

7.1.5 Indoor Exhaust Ventilation :

Local exhaust or positive ventilation is not required in the spaces of 1400 m3 or over, provided: (a) Welding bays have unrestricted cross ventilation (b) Work is not carried out inside restricted spaces such as tanks and boilers (c) Every welder has about 280m^3 space.(d) Ceiling heights are more than 5m. (e) Process does not require the use of inert gas.

In case the above conditions are not met, mechanical ventilation at the minimum rate of 56m3/ min of air per welder is to be provided with a velocity in the direction of hood of 30m/min at the point of welding. The duct diameter and air flow volumes that would produce the control velocity using a 7 cm wide flanged section is given in the following table:-

Distance from arc or torch, fm.,	Minimum air flow, m^3/ min	Duct Diameter cm.
10 to 15	4.5	7
15 to 20	8.0	9
20 to 25	12.0	11
25 to 30	17.0	13

For hoods without flanges, minimum air flow shall be increased by 60 m"/min. I cm duct dia is based on relatively 1200 mt/min velocity in pipe.

7.1.6 Personal Protection :

For the safety and health of the workers, precautions have to be taken to safeguard against the various physical and chemical hazards. Maintenance of the equipment and proper care in the use, adequate ventilation etc. may reduce some of the hazards, but it may not be possible to eliminate all the hazards and hence the workers have to be supplied with suitable personal protective equipment. Since a helper is always posted near the place of work, he too has to be provided adequate protection.

Ordinary clothing may be sufficient to protect against UV and IR radiation, but some exposed areas such as face, wrist, neck, hands etc. would be affected. Asbestos/leather gloves may be useful to protect hands from electric shocks, heat and sparks.

Eye protection is the most irritical problem. Hence the measures have to be taken to stop flying particles, glare and the radiation. Since the welding temperature for various materials may be different, different types of shades may be needed for different jobs, and at the same time clear glass may be needed while chipping the weld.

If possible the welding operation in a shop floor be isolated and screened so that other workers engaged nearby are not affected. However, measures should be taken to protect the crane drivers and others from the hazardous fumes, rays etc., of welding operation.

To protect the workers from the toxic fumes, suitable respiratory protection should be provided.

Cotton apron if used by the workers maybe treated with fire retarding chemicals.

When there is a risk of materials falling on the workers, suitable hard hats may be provided. While doing electric arc welding, instead of holding the shield in one hand, it is advisable to wear a welder's helmet which protects the workers in many ways.

Refer Part-9 for further health & welfare measures.

7.2 Brazing, Soldering and Metalising Operations :

Such operations involve metal fumes because of heating. Inhalation of fumes (toxic or irritating) should be removed by local exhaust ventilation. Lead oxides and chlorides are released when soldering with lead-tin solder and zinc chloride flux. Lead oxides and formaldehyde are released when soldering with rosin core solder. Hazards of different types of solder should be known before starting work.. Hazardous contaminants should be measured by air sampling. Lead solder particles should not be allowed to accumulate on the floor or work tables. For protection against spattering of solder or flux, workers should wear faceshield or do the work under a transparent shield.

Respirators are required to protect against metal dust or fume while metalising or burning of metal. Hand gloves can protect against burns. Insulated, noncombustible holders can protect against fire and burns. Table cover should be heat resistant.

7.3 Finishing Operations like Polishing, Buffing, Cleaning, Shot Blasting :

Polishing wheels are made of leather faced wood or stitched canvas disks or similar material coated with abrasive glue on the periphery of the wheels.

Buffing wheels are made of disks of canvas, linen or felt with a coat of mild abrasive, tripoli or rouge.

Brush or scratch wheels are made of protruding wires and used to remove burrs, scale, sand and other materials.

While cleaning or finishing rough or ground jobs by air, sand or shot (metal) blast cleaning or polishing and buffing by rotating wheels, main hazard is dust (abrasive or metal) generation during such operations. It should be removed from the point of origin by an efficient exhaust system. Room dust (flying) should be collected by wall exhaust fans. Dust collectors should be cleaned regularly.

Shot Blasting by small metal balls (ferrous or nonferrous) is done through an air gun (jet). Pressurised air is passed through metal balls and they are shot blasted on metal plate, rough casting or any job requiring such shot blast cleaning. Because of air jet (force) surface is cleaned (corrosion removed) but metal and other dust is heavily generaged. It can spread and fly nearby. Therefore a close chamber is constructed and worker does this operation inside. For dust collection, powerful exhaust system with blower and dust collection chamber is required. The worker (blaster) wear full face protection and also use air line respirator to inhale clean air comming through it. Blasting chamber door should have glass window to watch worker inside. In case of difficulty he should come out. His medical examination for dust exposure and chest X-ray are necessary.

Sand blasting is prohibited.

Workers should wear eye protection and dust filters rather full face protection."

By pre cleaning of casting or machined part by keeping it in a rotating barrel, mill or abrasive chamber in close condition, subsequent dusting can be minimised.

The space around dust generating or cleaning process should be kept dry, clean and free from obstructions.

Solvent cleaning of metal parts pose fire and toxic hazard. Non-toxic or non-flammable solvents or cleaning agents like alkaline solutions are safe in this regard. Oil and grease should not be allowed to mix with cleaning compounds. Carbon tetrachloride and petrol are banned for cleaning purpose. Ventilation is needed to remove vapours.

Polishing and buffing wheels require :

1. Substantial stands and rigid mounting of wheels.
2. Guards to avoid contact with protruding nuts and the ends of the spindles.
3. Exhaust hoods to drive away the dust and flying particles. More than one branch pipe may be provided depending upon the shape and size of the pieces being worked.
4. Speed within the limit (15 to 35 m/s) when variable speed motors are used.
5. Avoidance of hand gloves.
6. A jig to handle the work against the wheel.
7. Not more than 3 mm clearance between the work rest and the wire brush wheel and use of leather or heavy canvas aprons, gloves and face shield while working on wire brush wheels.
8. Monitor procedures same as for grinding wheel.
9. No smoking while buffing or polishing as a spark pulled into the exhaust system might cause a fire.
10. No common exhaust systems for polishing, buffing and grinding operations because of the fire hazard.

7.4 Selection, Care and Maintenance of Equipment and Instruments :

Equipment and instruments for welding and cutting, brazing, soldering, metalising and finishing operations like cleaning, polishing and buffing require careful selection, use and maintenance for avoidance of hazards and accidents.

For protection against hot sparks, arc radiation and glare, fumes and gases, compressed gases, chipping slag, metal and abrasive dust and electric shock, goggles, helmets and shields should be worn by operators, welders and their helpers. These equipment should conform to IS. Welder's handbook SP-12, welding equipment for eye and face protection 1179, protective filter 5983 and IS guides for selecting the correct filter lens for welding and cutting operations, dust filters, gas respirators, breathing apparatus, protective clothing and other personal protective equipment must be referred. See Chapter-25 for such PPE and Chapter-26 for the First-Aid.

Sampling, identification and safe removal of gases, fumes and dusts by proper instruments and exhaust ventilating equipment are required first. Such instruments should be of good quality, well calibrated and properly maintained. They should be handled by trained personnel. Selection is dependent on job to be carried out, toxicity and concentration of gas or dust and working environment.

Welding equipment (e.g. torch) should not be used in a confined space. Welder's safe breathing zone requires at least 280 M3 space per welder and ceiling height more than 5 m. If natural cross ventilation is not sufficient, mechanical ventilation (local exhaust, local forced, roof or wall exhaust fans etc.) is necessary. They should be maintained efficient and with sufficient capture velocity. Welding partitions may be used to protect eyes of surrounding people.

As oxygen alone cannot burn, acetylene, hydrogen or other fuel gases are used with torches. For example, propane, propylene and their mixtures are used in gas cutting. Such gases are filled with pressure in metal cylinders. Therefore they should be safely handled. Foregoing Part 7.1.2 contains safety precautions for handling and storing of gas cylinders. See Part 8.4 of Chapter-18 also.

Manifolds are used to centralise gas supply at a rate higher than that of a single cylinder. Regulators, headers and distribution pipes are used therewith. They should be properly designed, erected and colour-coded. Oxygen manifolds should be located away from the source of ignition or flammable material. Leak detectors with alarm are desirable in manifold room.

Hoses and hose connections should be fully safe. Colour coding (e.g. red for fuel gas, green for oxygen and black for inert gas, see IS booklet) should be followed to avoid wrong connection. Special torch connectors with built-in-shut-off valves are available. Connections should be of ferrule or clamp type. Special tools for special threads should be readily available. External metallic covering on hose pipe is not desirable. Flashback devices (NRV) between torch and hose can prevent flashback into hoses and regulators. Burned hose section should be replaced by new one.

Gas torches should be of approved type. Cutting torches differ from welding torches in jet and valve design. Select proper welding head for mixture, tip or cutting nozzle according to the charts and screw it firmly into the torch. Do not use matches to light torch. Use a lighter. Safe operating procedure should be followed for welding or cutting.

In resistance or spot welding, point of operation should be guarded by enclosure, gate, two-hand control or similar safety guard. Back doors of machine and panels should be locked or interlocked. Control circuit should operate at low voltage (24 to 36 volts). A flash welding machine should have a shield or hood to control flash and fumes and a ventilating system to carry off the metal dust and oil fumes. Air or electrical foot switches should be guarded to prevent accidental operation.

In electric arc welding machine (AC or DC) current values should be kept minimum to avoid heating. Electric cables should be well insulated and automatic voltage controller should be used.

Electrode holders should be fully insulated to avoid shock or arc burn. Proper holder should be selected (heat resistant) depending on light or heavy work. Connections between cable and holder should not be loose. Hot holder should not be dipped in water for cooling. Bare electrode or holder should not touch the skin or wet clothing.

Holders for brazing and soldering operations should be made of noncombustible material and insulated to avoid fire and burn hazards. The best holder completely encloses the hot surface and so inclined that the weight of the iron prevents it from falling out.

Exhaust hood, duct, dust collector, fan etc. should be regularly inspected for choking, velocity, leakage etc. and kept clean for good working.

Gloves should not be worn by polishers and buffers to avoid dragging of hand. If the motors that drive polishing/buff ing wheels, have adjustable speed controls, the controls should be kept in a locked box and the speed shall be changed only by an authorised person.

While working on wire brush wheels, leather gloves, leather or canvas aprons and face shield should be worn.

Equipment and instruments should always be used in accordance with the manufacturer's instructions.

8 HEAT TREATMENT OPERATIONS:

After hot or cold working of metal, stress and strain are produced in the metal. Therefore heat treatment methods are required to remove these stresses.

8.1 Meaning and Types of Heat Treatment Methods:

Heat treatment can be defined as an operation of heating and cooling of metals in the solid state to induce certain desired properties into them. It is generally employed to improve grain size, machinability, mechanical properties e.g. tensile strength, hardness, ductility, resistance to wear heat and corrosion, magnetic and electrical properties or to relieve stresses in the metal produced because of cold or hot working. The common heat-treatment operations are annealing, normalising, hardening, tempering, carburising (case-hardening), cyaniding, nitriding, induction hardening and flame-hardening.

Heat treatment of rolled products are divided into two groups :

1. Processes involving holding for a long time at a specified temperature and slow cooling i.e. annealing and tempering.
2. Processes where metal is only heated in a furnace to a specified temperature and then cooled in air (normalising) or in liquid quenchers (hardening).

Some heat treatment processes are carried out with some chemical compounds as under :

Case hardening : Wrought iron is heated in contact with potassium ferrocyanide where the ferrocyanide decomposes into carbon which hardens the surface of wrought iron to make steel.

Nitriding process : Steel containing 1% aluminium is heated in atmosphere of ammonia at 550600 °C. Nitrogen dissociated from ammonia reacts with iron and aluminium to form on the surface, iron and aluminium nitrides which produce compact and hard surface.

Sintering and Heat hardening : Sintering refers to a process wherein fuel is mixed with the ore and burned on a grate. The product is a porous cake. Heat hardening or induration is done by combustion of gases passed through the bed to harden the pellets without fusing them together, as is done in the sintering process.

In addition to' agglomeration, carbonates and sulphates may be decomposed or sulphur may be eliminated. Non-ferrous sinter is produced from oxides and sulphides of manganese, zinc, lead and nickel. Heat hardening of green iron ore pellets is accomplished in a vertical shaft furnace, a travelling grate machine or a grate-plus-kiln combination.

8.2 Hazards and Safety Measures:

Hazards in heat-treatment are :

1. Burns due to high temperature heating (between 700 to 1100° C).
2. Hazards of chemicals like N_2, NH_3, NaCN, Na_2CO_3, NaCI.
3. Contact of quenching media like brine, water, oils, air and solution of NaOH or H_2SO_4 in water etc.
4. Hazards of various types of furnaces and temperature measuring instruments and electrical apparatus.
5. Handling of machine parts viz. steel castings, forging (shafts, axles etc.) springs, gears, wires, drills, screw taps, hammer dies, die moulds, high speed cutting tools and speed etc. for heat treatment purposes.
6. Lifting and travelling mechanism and their unguarded agency parts.
7. Dust exposure.
8. Hot surfaces and high air temperatures.
9. High humidity and air velocities.
10. High voltages and electromagnetic radiation.
11. High noise levels.
12. Infra-red radiation.
13. Excessive brightness of illuminated surfaces etc.

Control Measures are as under:

1. Exhaust ventilation to remove chemical vapours, fumes, gases, flammable or explosive dusts, vapours etc. An enclosing hood projecting over the entire tank and enclosed on two to three sides is preferable. A lateral exhaust (slots in top edge of the tank walls for horizontal air movement), convenient canopy hood, general room ventilation and a push-pull system (where out door air is blown across the tank into the exhaust hood) can also be employed. Exhaust hoods or slots should be so located that harmful fumes or dusts should not enter the breathing zone.
2. Flameproof or non-sparking fans and motors should be utilised in flammable area.
3. Monitoring of HCN or NaCN is necessary.
4. Excessive heat should be removed away.
5. Air supply to the furnaces should be uninterrupted and well controlled.
6. Adequate methods of storage, handling and disposal are desired.
7. Furnaces, ovens, dryers etc. should be gas fired or heated electrically. The use of solid or liquid fuel may be allowed in exceptional and justified cases.

8. Hardening tanks, quenching and pickling baths, shaft furnaces etc. should be projected about I m above the working level. If this is not possible, they should be fenced.

8.3 Hazards and Control from Treatment Media:

Part 4.3.1 explains that iron ore contains iron oxides, carbonates and sulphides, cast iron contains carbon with some sulphur, phosphorous, silicon and manganese, wrought iron contains carbon and other impurities, steel contains carbon and manganese. Table 20.1 gives percentage of chromium, tungsten, nickel molybdenum and silicon. In steelmaking processes it is also mentioned (in Part 4.3.1) that impurities of Mn, Si and C burn to give MnO_2, SiO_2, CO and $MnSiO_3$, furnace lining of SiO_2 and CaO.MnO give slag and in electric arc furnace phosphate and other slag is poured out.

Part 8.1 explains heat treatment with chemical compounds like potassium ferrocyanide, iron and aluminium nitrides, carbonates and sulphates and nonferrous sintering with oxides and sulphides of manganese, zinc, lead and nickel. Hazards of chemicals like N_2 NH_3, NaCN, Na_2CO_3, NaCI, NaOH, H_2SO_4 are also indicated.

Above chemicals behave as treatment media in the form of impurity, alloying material, furnace lining and chemical for direct reaction. NaCN may evolve HCN a poisonous gas. CO and NH_3 are also toxic. All metal waste and carbon, lime, phosphate, sulphate, chromium, nickel and cyanide waste are hazardous. It cannot be disposed off here and there. Cyanide being very toxic needs incineration i.e. controlled burning. Gaseous waste like CO and HCN should be passed through incinerator or flare and burnt. CO_2 is vented off through chimney.

Solid toxic waste should be treated to make less hazardous and then buried in permitted land with proper lining to prevent its penetration to spoil soil. From top it should be covered safely. Non-toxic slag/waste may be used for non-fertile land filling. CaO waste, because of its alkalinity, is useful to grow some plants (not all). Steel slag is used to make tough roads.

Liquid waste/effluent should be treated by appropriate chemical or biological methods and discharged with safe limits prescribed.

Special disposal methods should be employed depending on type of chemical, its concentration and biological effect.

Thus heat treatment operations should end in safe disposal-of final waste for the safety of people, bioculture and environment.

Health Precautions:

They include
1. Eliminate and prevent long time exposure to the hazardous fumes due to heat treatment.
2. Medical health check up of workers.
3. Provision and maintenance of effective controls for fumes and chemicals.
4. Use of personal protective equipment.
5. Training to workers and prompt supervision.

9. GENERAL HEALTH HAZARDS AND CONTROL MEASURES IN ENGINEERING INDUSTRY

Effects of dusts, fumes, heat, noise and vibration due to hot and cold working of metals and crush and other injuries due to machine tools are discussed earlier.

Foundry operations like sand handling, sand sieving, sand mill operation, mould making, core making, knockout operation, repair and relining of furnaces and ladles, and metal finishing processes like casting cleaning, fettling, chipping, brushing, air blast cleaning, dry grinding, polishing, buffing and shot/ sand blasting generate dust which contains silica. This may cause silicosis, a serious form of pneumoconiosis resulting in permanent lung damage. It is a notifiable disease under the Factories Act, Mines Act and the Workmen Compensation Act.

Iron dust is exposed to iron foundry workers, electric arc welders and workers doing dry grinding, buffing, polishing and shot blasting. Siderosis is caused due to inhalation of such iron dust (Iron oxide).

Coal dust is generated at furnace, boiler and coal handling work and may cause anthracosis i.e. coal workers' pneumoconiosis. This lung disease may result in more serious progressive massive fibrosis (PMF) leading to a premature death.

Engineering controls include exhaust hood, substitution of wet grinding for dry grinding, hydro blasting for sand/shot blasting etc. and built-in dust collecting devices with dust generating machines. In addition, workers should wear safety goggles and dust masks or proper respirators.

Medical controls include pre and post employment medical examinations including X-ray, sputum test, lung function test etc. Epidemiological analysis of dust exposure can provide a measure of efficacy of a dust control device.

High noise in pneumatic chipping, resistance welding and other engineering operations can cause auditory effects of hearing loss and occupational deafness (a notifiable disease) and non-auditory effects of change in heart rate, blood pressure and sweat rate, annoyance and disturbance in work and psychological and psychomotor effects.

Engineering controls for noise include substitution of quieter machinery, quieter process, enclosure to noisy equipment (e.g. silencer, noise insulators etc.) or/and enclosure to operators (soundproof cabin). Workers should wear ear plugs/ muffs where necessary.

Medical controls include pre and post medical examinations of workers, audiometric tests for hearing capacity and change of work area if necessary.

Painting and spraying on castings or finished parts evolve fumes which may be toxic and/or flammable. Proper spray painting booths with air suction and water curtain are necessary. Safety goggles, fume mask, hand gloves and apron should be worn. Dipping is preferred to spraying.

Workers working near excessive heat (e.g. furnaces, molten metal, glass blowing etc.) should be given cold drinks or water and heat protective clothing to reduce heat effect. Heat source should be shielded by insulation and reflectant or absorbent shields. Natural ventilation to allow cool fresh air, induced cool dehumidified air into hot workplaces and local blowers to give individual relief are useful for comfort.

For protection against skin effect due to cutting or lubricating oil, coolant etc., proper gloves, barrier creams and medical advice are necessary.

Health measures including general cleanliness, disposal of wastes and effluents, good lighting and ventilation, temperature control, dust, fume and gas removal, humidity control, drinking water, latrines, urinals and spittoons and avoidance of overcrowding, as expected under the Factories Act and Rules are the statutory requirements.

Welfare facilities should include washing and bathing facility, drenching showers, emergency shower, eye washer, sitting arrangement, cloak or change room, lockers, rest room, lunch room, canteen, creche, 'towels, soaps, first-aid centre and medical help etc.

E X E R C I S E

1. Explain, State, Mention or Discuss:

1. The need of Safely in Engineering industry.
2. Statutory provisions for Engineering factory.
3. Hazards and safety precautions while working on furnaces.
4. The manufacturing process of steel.
5. Safety measures for steel manufacturing.
6. Flow sheet for foundry operations. Explain by chart.
7. Section wise foundry operations, their hazards and safety measures.
8. Provisions of Sch. 26, Rule 102, GFR for foundary operation.
9. Types of accident in a forge shop and general safety measures required.
10. Specific safety measures necessary in forging operations OR in forging furnaces.
11. Machine guarding of Forging hammers.
12. Safe work practices in forging operations.
13. Safety in design and handling of forging dies.
14. What do you mean by cold working of metals?
15. Types of guards recommended for power presses.
16. Control measures for hydraulic and pneumatic presses.
17. Sequential operations of wire drawing process, their hazards and safely measures.
18. Hazards and controls of any three of the following machine tools(A) Lathe (B) Drill (C) Milling m/c (D) Grinding m/c
19. Safety measures while working on a grinding machine.
20. What do you mean by a CNC machine? Explain its safety and handling precautions.
21. Precautionary measures for preventing welding fires.
22. Safety aspects of Gas welding and cutting.
23. Provisions of Sch. 24, Rule 102, GFR for welding and cutting operations.
24. Safety in handling and storing of gas cylinders OR safety in regulators and hose connections.
25. Precautions against electric shock due to Arc welding.
26. Precautions while working on polishing and buffing wheels.
27. Hazards and safety measures of heat treatment operations.
28. Different types of media used in heat treatment methods, their hazards and controls.
29. General health hazards and control measures in engineering industry.
30. What PPE you will suggest for following operations.
    (a) Fettling work (b) Hot forging work (c) Polishing and buffing (d) chromium plating (e) Acid cleaning (f) Solvent washing (g) Electric welding (h) Noise due to hammer.

2. Write Short Notes on :

1. Type and purpose of furnaces.
2. Special alloy steels.
3. Bessemer OR Open Hearth process to manufacture steel.

4. Electric Arc Furnace.
5. Main hazards in steel manufacture.
6. CO hazards in steel furnaces.
7. Hazards and safety measures for moulding process OR melting and pouring process.
8. Floor condition in foundry OR Mechanised foundry.
9. NDT for casting.
10. Forging furnace, hazards and controls.
11. Stuck forging.
12. Tongs for forging operations.
13. Safety aspects of hot rolling operations.
14. Hazards and controls of Hot Rolling Mill.
15. Seven principles of guarding for cold working machines.
16. Safety devices for hand and foot operated presses.
17. Hazards and control devices of Press brakes.
18. Cold rolling mill-Hazards and control measures.
19. Classification of machine tools.
20. Causes of accidents and control measures for Grinding wheels.
21. Angles of guards for different types of Grinders.
22. Selection and care of Cutting tools.
23. Safe operation and maintenance of machines.
24. Common causes of fires in welding and cutting.
25. Electrode holder.
26. Hazards of Electric (Arc) welding.
27. Fumes in Arc welding and precautionary measures.
28. Welding in a confined space.
30. Buffing operation.
31. Ring test of a grinding wheel.

3. Explain the Difference between

1. Hot processes and Cold processes
2. Melting furnaces and Heating furnaces.
3. Fuel fired furnaces and Electric furnaces.
4. Cast iron. Wrought iron and Steel.
5. Kiln and Oven.
6. Flame furnaces and Shaft furnaces.
7. Knock out operation and Fettling operation.
8. Sand blasting and Shot Blasting.
9. Forge press and Trim press.
10. Hot rolling and Cold rolling.
11. Shearing and Hammering.
12. Power press. Press brake and Bending m/ c.
13. Shear and Slitter.
14. Machine tool and Hand fool.
15. Planing m/c and Shaping m/c
16. Broaching m/c and Slotting m/c
17. Machine tool and Cutting tool.
18. Two-hand control device and Photo cell device.
19. Die enclosure guard and Push (sweep) away device
20. Welding and Cutting.
21. Gas welding. Arc welding and Resistance welding
22. Polishing Wheel, Buffing Wheel .and Scratch wheel.

23. Case hardening and Nitriding.
24. Sintering and Heat hardening.
25. Siderosis and Anthracosis.

4. Comment on following explaining whether it is true or false ?

1. In melting furnace, materials being processed remain in the same state of aggregation while in heating furnace they change their state of aggregation.
2. Forging is a hot process only.
3. Rolling operation may be hot or cold.
4. Electric arc welding is possible by AC or DC both.

5. Explain the following terms :

1. Cementile crucible steel
2. Reverberatory furnace.
3. Cementation process.
4. Core making.
5. Cupola furnace.
6. Pouring aisle.
7. Parting materials
8. Die sinking
9. Trim press.
10. Alligator shear.
11. Forming rolls.
12. Machine tool.
13. CNC machine
14. Auto tool changer
15. Hand feeding tools.
16. Total productive maintenance (TPM).
17. Brazing or soldering.
18. Gas torch.
19. Heat treatment
20. NDT.
21. Siderosis
22. Safe peripheral speed.
23. Self acting machine.
24. Pickling process of metal.
25. Point of operation guard.
26. Treadle guard OR Scale guard (shield) of a forge hammer.
27. Work or tool rest.
28 Flash hack OR backfire.

Reference and Recommended Reading

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CHAPTER – 21

Safety in Textile Industry

THEME

1. NEED OF SAFETY IN TEXTILE INDUSTRY

Clothing is the basic need for all of us and with the modernisation a want of more and more attractive (durable, shining, anti-crease and colourful) fabrics is increasing day by day. Therefore the foundation of textile industry is very old, ever changing and ever lasting. The continuous blow room line, replacement of mule spinning by ring spinning, rotor spinning, high speed shuttle-less and workerless looms and computerised processing machinery has rapidly changed the structure of textile industry and the mills not following such modernisation and automation are becoming sick in market competition. Yet it is a fact that the old textile machines are still in use in some mills. From safety point of view, such old and poorly guarded (and without built-in safety) machinery needs more attention.

Indian textile industry is the oldest one in the world. Cotton was invented and planted "by 'Grutsmad' Rushi some 20,000 years ago. Yarn and threads were manufactured by hands and cloth was woven by hand looms. A reference is published that a ginning machine made in India was sent to England. Dhaka's 'malmal' (the thinnest and lightest cloth) was famous. British rulers cut off the palms and fingers of Indian weavers so that they cannot compete with cloth from England. Dyeing by natural colours was also in use. Old Indian garments were white and colourful.

The textile mills established during 19th century in Lancashire and in New England initiated the Industrial Revolution and their cotton fabrics dominated the world markets for many years. Indian textile mill industry is also as old as the first Indian Factories Act 1881 and Gujarat is still leading in textile industries. Man made synthetic fibres such as polyamides and polyester are now blended with cotton and a trend of such artificial fabrics is increasing.

In 1979 there were 19728 cotton textile factories working with 1147000 workers and 3244 wool, silk and synthetic fibre factories working with 179000 workers out of total 135173 working factories with total workers 6797000 in India. This gives 10.33% textile (cotton and others) factories and 19.50% textile workers.

In 1999 estimated registered textile factories in India and Gujarat were ©16000 and 4000 respectively. Similarly estimated textile workers in India and Gujarat were @14 lakhs and 3.0 lakhs respectively.

Table 5.16 of Chapter-5 gives following figures of textile factories in Gujarat as on 31-12-2001.

NIC Code (for Textile)	Working Factories	Average Workers
17	2634	163714
18	170	9284
Total	**2804**	**172998**

This indicates there was 13.21% textile factories (cotton, man-made fibres, wool, silk, jute and textile products) and 19.07% textile workers in these factories in Gujarat in 2001.

Any estimate of unregistered textile factories is vague. Most of such weaving and texturising units employing less than 10 workers are many times more than the registered weaving factories. For example, against 100 registered factories, an estimate runs up to 10,000 unregistered (partitioned) establishments.

Therefore in want of correct and latest statistics, it seems difficult to figure out total textile factories and textile workers.

Table 5.6 (Chapter-5) gives following figures for textile industry in India for the year 1992 :

Accidents	Fatal 67, Nonfatal 33047, total 33114
Incidence Rate	Fatal 0.02, Nonfatal 8.55
Frequency Rate	Fatal 0.03, Nonfatal 14.80

Table 5.19 (Chapter -5) gives following figures for textile accidents in Gujarat :

Type of Accidents	1996	1997
Fatal	32	36
Nonfatal	3978	6967
Total	4010	7003
Percent of total textile & non-textile fatal & nonfatal accidents	35.62	58.02

Thus total textile accidents occupy nearly 35 to 55%- of all industry accidents in Gujarat. This indicates high need to control textile accidents.

US incidence rates for the year 1995, of some textile processes are as under :

Carpets & rugs	10.0	Yarn & thread mills	9.1

Knitting mills	8.2	Wool fabric mills	7.5
Manmade fabric mills	6.1	Cotton fabric mills	5.8
Textile finishing	7.8	Misc textile goods	12.0

Comparing with all manufacturing incidence rate 11.6, it indicates little higher proportion of accidents in textile industry in USA (Accidents Facts, 1997, NSC).

A case study of one good composite textile mill employing @3500 workers indicates following figures :

Year	1984	1985	1986
Total accidents	281	343	368
Due to unsafe conditions	135 (48%)	161 (47%)	156 (42%)
Due to unsafe actions	146 (52%)	182 (53)	212 (58%)
Mandays lost	2100	7276	3995
Frequency	32.78	40.25	45.04
Severity Rate	245.04	849.0	466.16

The department wise accidents in above study give following figures for the year 1986.

1.	Weaving	111	6.	Bleaching, Finishing Lab etc.	23
2.	Engineering	51	7.	Dyeing	22
3.	Contract workers	65	8.	Folding, Store, Office	15
4.	Spinning	53			
5.	Printing	28			
				Total	368

The causation wise accidents in above study gives following figures for the year 1986 :

1.	Striking against objects	103	6.	Fall from height	24
2.	Struck by falling bodies	48	7.	Burn by hot substance, chemicals etc.	16
3.	Cut by sharp edges knife, tools etc.	34	8.	Cut by bobbin shields	14
4.	Caught between objects	30	9.	Others	72
5.	Flying shuttles	27			
				Total	368

Another case study of 2100 accidents in II composite mills, carried out by the Central Labou Institute, Bombay gives following figures :

S. N	Department	Accidents	Percent
1	Spinning Preparatory & spinning	738	35.2
2	Weaving Preparatory & Weaving	1019	48.6
3	Finishing & other Departments	343	16.2
	Total	**2100**	**100**

Agency distribution is as follows

S. N	Agency	Accidents	Percent
1	Looms	617	29.4
2	Ring Frames	321	15.3
3	Other Machines	335	15.9
4	Material Handling	228	10.9
5	Working Conditions	202	9.6
6	Hand Tools	176	8.4
7	Hand Trucks and Transport Equipment	121	5.8
8	Chemicals	34	1.6
9	Others	66	3.1
	Total	**2100**	**100**

Above statistics ascertains that the textile industry is one of the biggest industries in India employing more than 20% of total labour force and contributing more than 50% of total industrial accidents thus highlighting the great need of safety and accident prevention in this industry. Heavy and numerous machineries, health hazards including machine accidents, shuttle flying, cut by bobbin shield, byssionosis, heat stress, humidity, high noise, fire hazards and higher number of employment also stress for the higher need of safety.

Almost 50% accidents occurring in textile industry are due to unsafe conditions. Therefore machine guarding and other safety conditions need much attention. The latest design of textile machinery having built-in safety, dust suction device and computer controls has eliminated many hazards of old machinery.

2 TYPES OF TEXTILE INDUSTRY

Cotton being the natural and old product, light, human body (particularly for hot days), cotton textile is pioneering and oldest industry. But with invention; of new fibres, natural and synthetic, it has, now become a mixed industry. The industry includes the spinning, weaving, knitting and finishing of all type; of natural, synthetic and artificial fibres. The machine; vary from handlooms of cottage industry to very expensive and intricate modern machines. Some are only spinning mills, weaving units or dyeing and finishing houses while some are composite textile mill; carrying out all operations at one place.

A classification of various types of the fibres is as follows :

- **Fibres**
  - **Natural Fibres**
    - Vegetable Origin
      - Cotton, From Seeds & Fruit, Kapok, Coir
      - Jute, From Bast, Flex, Hemp, Ramile, Sisal
      - From Leaf
    - **Animal Origin**
      - Wool, alpaca, mohair, goat, camel hair
      - Silk & other filament
    - **Mineral Origin**
      - Asbestos
        - Amphiboles, Actinolite, Amosite, Anthophyllite, Crocidolite, Tremolite, Serpentine, Chrysotile
      - Wollastonite
        - Zeolite, Sepiolite, Attapulgite
  - **Manmade Fibres**
    - Artificial Fibres (Natural Polymer)
      - Viscose rayon (artificial silk)
        - Cupra rayon, Filament and Staple fibre
      - Cellulose ester
        - Cellulose acetate, Cellulose triacetate
      - Protein fibres from milk, seaweed, maize-soya ground-nuts
    - **Glass & Chemical fibres**
    - Glass fibres made from borosilicate or calcio alumina silicate glass (Glass wool)
    - Synthetic Fibres (Petrochemical Origin) Polyamides (Nylon), Polyesters Polyolefins (Courlene), Polypropylenes Polyurethanes (Spendex fibres)
    - Polyvinyl derivatives (Acrylic Fibres)
      - Polyacrylonitrile, Polyvinyl chloride, Polyvinylidene chloride, Polyvinyl alcohol, Polytetrafluoro ethylene & related polymers (Teflon), Polyvinylidene dinitrile, Polystyrene and Miscellaneous.

All these fibres are used for various purposes such as garments, protective wears, ropes, carpets etc. They are the raw materials for various types of textile industries.

3 STATUTORY PROVISIONS

3.1 General:

Section 15 (Artificial humidification), 27 (Cotton openers) and 31 (Pressure plant) of the Factories Act are generally applicable to textile plants. The Gujarat Factories Rules has made some specific provisions by Sch. I & II under rule 54 and also under rule 68C & D,and Sch. 12, 23 & 27 u/r 102.

The statutory requirements are individual machine drive, belt shifting devices, inter locked covers for beaters, card cylinders, headstocks and dangerous parts, fixed fencing for dust chamber, beater grid bars, guards for lap and fluted rollers, nip guards for calendering machines etc., and a wall fencing with locked doors for the underground line shafts of ginning factories.

More details are provided by a substituted Schedule I under rule 54 of the Gujarat Factories (Amendment) Rules 1995. This schedule defines calendar, card, comber, combing machinery, rotary staple cutter, garnet machine, gill box, in-running rolls, interlocking arrangement, kier, ribbon lapper, sliver lapper, loom, starch mangle/water mangle, mule, nip, openers and pickers, paddler, plating machine, roller printing machine, continuous bleaching range, mercerizing range, sanforizing machine, shearing machine, singeing machine, slasher, stenter frame and warper. Safety requirements for these machines and other machines such as centrifugal extractors, rope washers, laundry washer, printing machines, plating machines, baling machines and flat work ironer are also prescribed. For details of Sch I & II u/r 54, see Part 4.4 of Chapter-14.

Rule 68C for polymerising or curing machine (fixing print by emulsion technique), requires thoroughly drying of printed fabrics, exhaust flap or damper, cutting off electrical heaters in emergency or solvent dropping, interlocking of the exhaust fan with main drive of the machine, thermostats to regulate temperature, explosion doors (flaps) to let off the fumes outside the workroom, weekly cleaning of filter gauge and exhaust dust, checking of V-belt tension, examination and a register therefore. See Part 3.3 for more details.

Rule 68D for thermic fluid heaters used to circulate hot oil in stenter and other drying machines, prescribes many provisions. See Part 10 of Chapter18 for details.

For Rule 68G, GFR, for Oven & Driers, see Part 27 of Chapter-23.

For Sch. 12 & 19 u/r 102, GFR, for chemical works, sets Part II of Chapter-23 and for Sch. 23 u/ r 102, for high noise, see Part 4 of Chapter-12.

Chapter-3 (Health), 4(Safety),5(Welfare), 6(Working hours), 7(Employment of young persons) and 8(Annual leave with wages) of the Factories Act are mostly applicable to textile factories as they are applicable to other factories.

Some relevant provisions of the Factories Act & Rules applicable to textile industry are mentioned below in brief.

3.2 Health Provisions :

Cleanliness (removal of cotton dust from work .area), disposal of waste and effluent from dyeing and printing processes, good ventilation, temperature and lighting, removal of dust and fume from dusty and heating area, artificial humidification required for cotton fibre strength, drinking water, latrines and urinals and spittoons are applicable health provisions under Chapter-3 of the Factories Act.

Artificial Humidification:

Section 15 of the Factories Act requires that water to be used to increase humidity of air artificially (mostly in spinning department) should be clean and from a source of drinking water.

Rules 19 to 29 prescribed u/s 15, require other details as under :

1. Artificial humidification is not allowed in spinning or weaving factory when room temperature exceeds 29.5°C (85°F) or when wet bulb reading of the hygrometer is higher than that specified in the schedule u/r 19 in relation to the dry bulb reading of the hygrometer at that time.
2. Provision of hygrometer.
3. Copy of schedule u/r 19 to be affixed near every hygrometer.
4. Temperature to be recorded in humidity register (Form No.6) at each hygrometer.
5. Specifications of hygrometer.
6. Thermometer to be maintained in efficient order.
7. Inaccurate thermometer not to be used without fresh certificate.
8. Hygrometer not to be affixed to wall etc. unless protected by wood.
9. No reading to be taken within 15 minutes of renewal of water.
10. Method of introducing steam for humidification (pipe dia < 2.5 cm , pressure < 5 Kg/Cm2 , jet projection < 11.5 cm , insulation thickness > 13 mm.)

Byssionosis is included in the third schedule of the Act as an occupational disease due to cotton dust exposures to workers. It is reportable u/s 89. For details see Part 10 of this chapter.

For monitoring and control of 'cotton dust' (TLV), new schedule 27, 'handling and processing of cotton' u/r 102 is added in GFR vide Notification dated 19-1-2006. It requires

1. Applicability to factories where any of the processes-opening of cotton bale, carding, combing of cotton, spinning of cotton yarn or cleaning of waste cotton - are carried out.
2. For removel of cotton dust, local exhaust ventilation is required on processes and machines where cotton dust is generated.
3. Workers should be given necessary PPE.
4. Six monthly madical examination for LFT, immunoglobulim test and any other test necessary.
5. Limit of cotton dust in workroom should not be more than 0.2 mg/m'\ Record of area monitoring should be available to the inspector.
6. Other control measures like vacuum stripping of cards and vacuum cleaning should be adopted.
7. High standard of houskeeping should be maintained.

3.3 Safety Provisions:

Section 21 of the Factories Act regarding general machine guarding is application to all textile machines.

Section 27 prohibits employment of woman or child in a cotton press room where a cotton opener works. If feed-end of a cotton-opener is separated by full partition, they can be employed on feed-end side. This is due to the risk of more flying cotton dust on delivery side and hit-injury when any revolving beater breaks or any solid material is thrown out on delivery side.

Hoist, lift and lifting machine provisions are applicable to those machines. Section 30 on revolving machinery is applicable to hydroextractor to remove water from wet fabric. The top cover of the revolving basket should be interlocked and safe working peripheral speed should not be exceeded.

Section 31 and rule 61 are most important for all pressure vessels to be used in a textile industry. Jet dyeing or beam dyeing vessels, ager, kier, drum washers, cooking-pans, drying cylinders, drying range, sizing cylinders, air receiver tanks etc. are all subject of this provision. Their design, construction, use and maintenance must be safe. They must be tested by a competent person periodically. Their safely devices like safety valve, pressure gauge, stop valve, drain valve and PRV or pressure regulator must be provided and maintained in a safe working condition. Steam traps and vacuum breakers are also essential.

Precautions against toxic or flammable gas and fire are also applicable to textile processes using solvent (eg. blancket cleaning) and cotton godowns.

Schedules I & II for detailed machine guarding u/r 54 are summarised in Part 4.4 of Chapter 14.

Rule 68C,GFR, provides following safety precautions for Polymerising and Curing Machines:

1. Printed fabrics shall be thoroughly dried before feeding to such machines (to allow less solvent in the m/c).
2. 2/3 portion of the exhaust damper/flap should always be open.
3. Infrared ray heaters shall be cut off while running the prints.
4. Electrical heater should have separate circuit and switch to isolate it at the time of emergency.
5. Leakage of solvent should not come in contact with the heaters.
6. Exhaust fan drive should be interlocked with main drive of the machine so that when exhaust motor stops, the machine (with heating device) should also stop. (Exhaust fan should start first before the fabric moves into the chamber).
7. Thermostat to regulate the temperature of the heater, not allowing it to go beyond the preset value.
8. Explosion flaps to be provided at top to let off the fumes in case of explosion.
9. Filter gauge and exhaust duct should be cleaned weekly. Vee-belt tension should be checked weekly.
10. Trained supervisor to examine the machine. A register to be maintained to enter all checks.

When thermic fluid heaters are used to circulate hot oil instead of steam in textile machines (eg. stenter for cloth drying) rule 68D, GFR, is applicable. See part 10 of Chapter-18 for details.

Rule 68E, requires suitable ladders, crawling board and work permit to prevent fall from fragile roofs..

Rule 102, Sch: 23 requires ear protection for noise level above 90 dBA, and -auditory examination every year. Weavers are mostly exposed to high noise. Sch. 27 requires protection from cotton dust.

Man-made Fibre (Cellulosic and noncellulosic) industry is listed in the First Schedule of the Act as a hazardous industry. Therefore while manufacturing such synthetic fibre. Chapter 4A of the Act and rules 68K to N, P and Q of the Gujarat Factories Rules are applicable. These provisions may be referred in statute books for details. Then Schedule 19 u/r 102 also becomes applicable for chemical work. Schedule 12 u/r 102 is applicable where acids or alkalis are used.

3.4 Welfare Provisions :

Chapter-S (Sections 42 to 50) of the Factories Act is fully applicable to textile factory. Washing facilities, first-aid appliances, canteen, lunch room and rest room, creche and welfare officers are required depending on number of workers employed.

Rules 68R to W of the Gujarat Factories Rules regarding health records, qualified supervisors, medical examination, occupational health centre, ambulance van and safety showers are applicable to hazardous processes in man-made fibre textile industry.

3.5 Cotton Ginning and Pressing Factories Act and Rules :

This old Act and Rules are applicable to cotton ginning and pressing factories.

Sch. 2, u/r 54, GFR requires wall or fancing for line shaft of gin machines. (Individually driven gins require separate guards.)

4 INDIAN STANDARDS

From a variety of IS on textile machinery, some are given below :

Textile motors 2972 (Part I for loom motors, Part II for card motors. Part III for spinning frame motors). Code for fire safety in cotton textile mills 3079, rings for spinning and doubling frames 3078, 6317, ring doubling and twisting frames 5938, 7614, ring frame, warp spindle 3698, tin rollers 838, metal travellers 3523, shaft bottom for cotton looms 833, shuttle blocks for automatic looms 9280, 9287, shuttles-classification of terms 8684, spinning frames-bottom rollers 2510, spindles 3934, top roller 3176, machinery nomenclature 6068, methods for identification of application classes of dyes on textile materials 4472 (Part I for cotton and cellulosic fibres, Part II for wool, silk and protein fibres. Part III for man-made fibres), natural fibres 2364, drafting in spinning machinery 4474, finishing machines, nominal widths 7952, treatment and disposal of effluents 9508, tolerance limits for effluents 2490 (Part I to 10), water for quality tolerances 201, twisting machinery 6068, warp bobbins 1724, warper's beams 9292, warp stop motion 3683, warp ring frame 3698, weavers 'beams 3165, weaving looms and preparatory machines 3199, weft pirns for shuttles 3265, winders-cone and cheese 8567, pirn 8568, winding rollers for finishing -machines 8304, wooden bobbins for ring doubling and twisting frames 7614, woven fabrics testing 9, 2977, 7903, 10100, yarn acetate and rayon filament 1229, blended 7866, polyester and polyamide 7703, 7867, cotton count determination 237, cotton winding cones 4888, twist determination 832, linear density determination 1226, textile conditioning 6359.

Cotton handloom colour fastness 6906, residual chlorine 2350, scouring loss determination 1383.

Dyes fastness 1688, Fibres, methods of identification 667, flammability and flame resistance test 11871, water quality tolerances 201, textile items made up, glossary 14281, processing glossary 9603, testing handbook SP'.15, textile terms - wool and animal fibres 11206, mmf 1324, natural fibre 232, woven fabrics 2364, textile belting 1891, floor coverings, flame resistance 12722, asbestos yarn 13362, electrical insulation and plastic laminate 13128.

5 FLOWCHARTS OF TEXTILE PROCESSES

5.1 Composite (Textile Mill) Flowchart:

It is essential to understand a textile process flow chart before proceeding towards the textile machines. Therefore it is shown below in Fig 21.1. General layout of a composite textile mill is shown in Fig. 21.2.

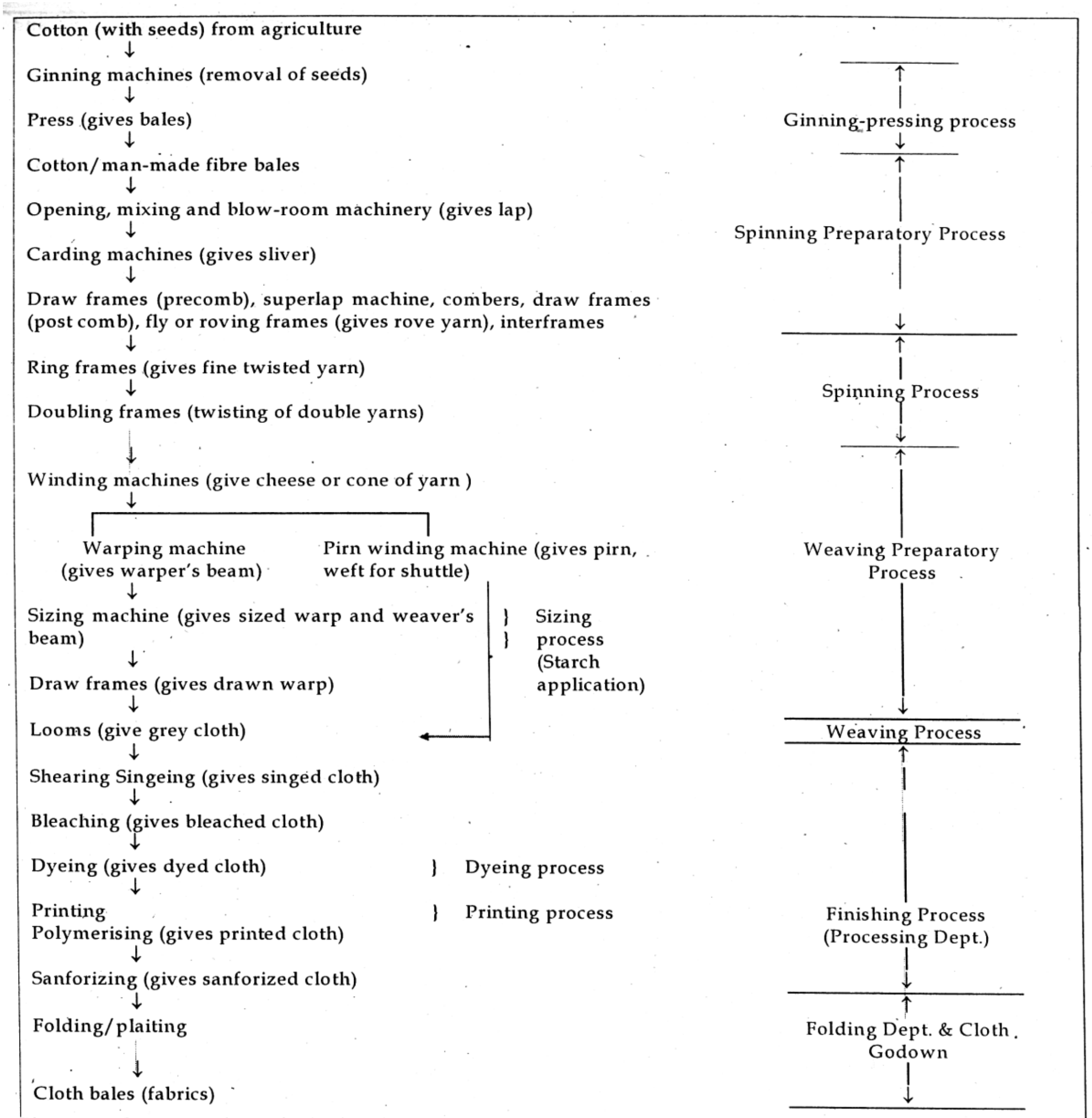


Fig 21.1 : Composite (Complete) Flowchart of textile processes

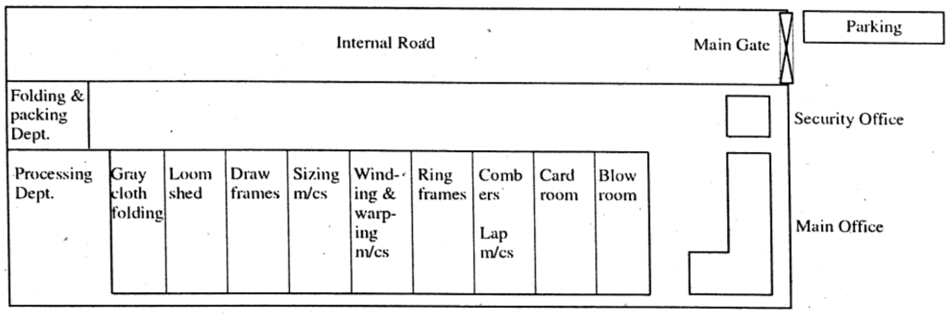


Fig. 21.2 Layout plan of a composite textile mill

Above flowchart is self-explanatory, yet some main processes are explained below :

Ginning : The fibres and the cotton seeds are separated by 'gin' machines in a ginning factory.

Pressing & Baling : The ginned cotton is compressed and packed into bales by cotton presses (mostly hydraulic) in a pressing factory. Generally ginning and pressing factories are combined and situated in villages where cotton is collected. The cotton bales are transported to a spinning mill or a composite textile mill. The cotton-seeds are separately collected. They are used to extract oil therefrom and also for cattle-food.

Schedule-2, rule 54, GFR is applicable to ginning and pressing factories while Sch-l is applicable to following processes.

Bale Opening and Scutching: In a blow room the bales are opened by bale openers, sometimes tinted in a tinting room for quality separation and mixed with cotton from other bales or man-made fibres through a hopper feeder. By a moving spiked lattice, beaters and a series of rolls the fibres are thoroughly mixed, cleaned and further opened by revolving beaters and air currents against a grid through which the dirt is separated. A cotton lap is formed and lap-rolls are sent to the carding machines

Carding : The fibres are made parallel to each other, remaining hard tuffs are broken and short thin fibres and impurities are removed. A sliver (flat untwisted rope) is formed and it is collected in cans.

Spinning : Through pre-comb drawing frames, sliver lap machines, comber machines, drawing frames and inter frames the sliver is converted into inter-end by drawing, drafting, combing and twisting processes. More slivers are passed through pairs of suitably spaced rollers, each pair revolving at a higher speed than the preceding pair. Further attenuation of the yam is accompanied by ring frames and doubling frames. Inter roving ends are converted into yarn of required count by drafting and twisting in the ring frame machines. A new method known as open-end or rotor spinning is most suitable for spinning coarse yarns and can replace not only the ring frame but some other initial processes as well. Texturising is done to synthetic yarn to reduce its denier.

Weaving Preparatory : In winding department yarn defect is removed and cheese and beam (by warping machine) are produced. Pirn bobbins are filled to put them in shuttles. Yarn singeing is carried out to burn off the projected fibres (hairs). Sizing (starch) process is carried out in sizing machines.

Weaving : After the weaving .preparatory processes, the warp threads (beams) and weft threads (pirn bobbins) are fed to looms to weave cloth. Various types of looms are used. New alternations to the shuttle for weft insertion are - rapier, water jet, air jet and ripple or wave shedding. The cloth is sent to the grey folding department for cleaning, mending, inspection and folding (plaiting) purposes.

Artificial humidification is employed in carding, spinning and weaving departments to reduce yarn breakage, because moist thread has relatively higher breaking strength than a dry thread. But high humidity causes discomfort. Therefore its regulation is required by hygrometers and by rules 19 to 29 under the GFR.

Finishing Processes : Here shearing - cropping, cloth singeing, piling, mercerising, drying, washing, desizing (removing starch by enzymes solution), scouring (removing fats and waxes by hydroxide solution), bleaching (by H,O, or Cl,>, dyeing (wide range of dyes available) and printing (screen or multicolour rotary printing) processes are carried out in sequence. The dyed or printed cloth is dried, smoothed and pressed. It may also be subjected to other treatments to improve its appearance or wearing qualities. It may be made waterproof, flame repellent or rotproof. Synthetic resins are used for these purposes. The finished cloth (fabric) is sent to finish folding department, for checking, sample cutting, folding and baling purposes.

Now we shall see the flowcharts of different types of fabrics.

5.2 Other Flowcharts:

To understand flowcharts of fabric manufacturing it is necessary to understand sequence or stages of manufacture from fibres to fabrics and then bleaching, dyeing, printing and other finishing processes on the fabrics.

The first stage in the production of a fabric is to clean and mix fibres thoroughly. The fibres are then generally straightened, but for the production of certain types of fabric they must be brought into a condition in which they are all parallel. The fibres are next drawn out into the form of sliver, which resembles a flat rope but with the fibres having no twist. Repeated drawing (extenuating) and twisting follow. This twisting is to give the resulting roving i.e. just sufficient strength to prevent breakage in its manipulation (extenuation). Thus a fine roving is produced which is finally twisted into yarn. The yarn is used to produce fabrics by either knitting or weaving.

It will be realised that for the carrying out of these manufacturing processes a wide range of different types of complicated machines and a great variety of methods are used. Such processes have taken more than two centuries to perfect and even now, partly owing to the increasing use of rayon and synthetic fibres, modifications are constantly being introduced.

Fibres are of two types - staple fibre and continuous fibre. Staple fibres are of certain lengths while continuous fibre is a very long filament made from chemicals. Continuous fibre can be cut to required lengths which may be short or long, for the purpose of mixing with other short or long staple fibres.

Short and Long staple Fibres :

Staple fibres are classified as short, medium or long. Normally less than 2 inch (5 cm) long are short staple fibres and longer than that are called long staple fibres. Wool is called short staple if less than 2.5 inch long and called long staple or worsted if more than 2.5 inch long. In short staple spinning process, gilling machine (gill box) is not used. In long staple process 'gilling' machinery is used to straighten the sliver. Carding is an excellent method for straightening and attenuating short fibres. Gilling is not satisfactory if the fibres are short. Therefore in the preparation of wool fibres for combing, it is preferred to straighten diem by carding if the fibres are less than about 9 inch (230 mm) in length and to gill if the fibres are longer, say up to 15 inch (380 mm) in length.

Long staple worsted wool, jute, coir and flex can be classified as long staple fibres, cotton as short staple fibre and man-made synthetic filament including -stretchable 'textured' yarn as continuous fibre.

Process flowcharts are shown from Fig 21.3 to

5.2.1 Process Flowchart of Short Staple i.e. Cotton Spinning and Finishing :

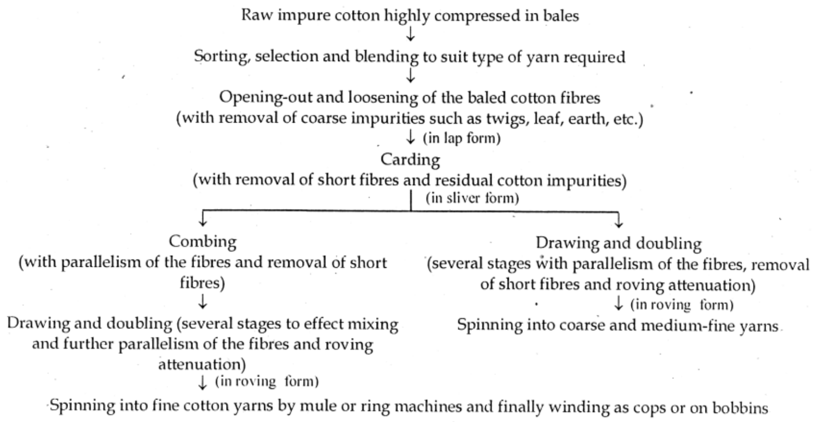


Fig 21.3 : Flowchart of Cotton (Short Staple) Spinning

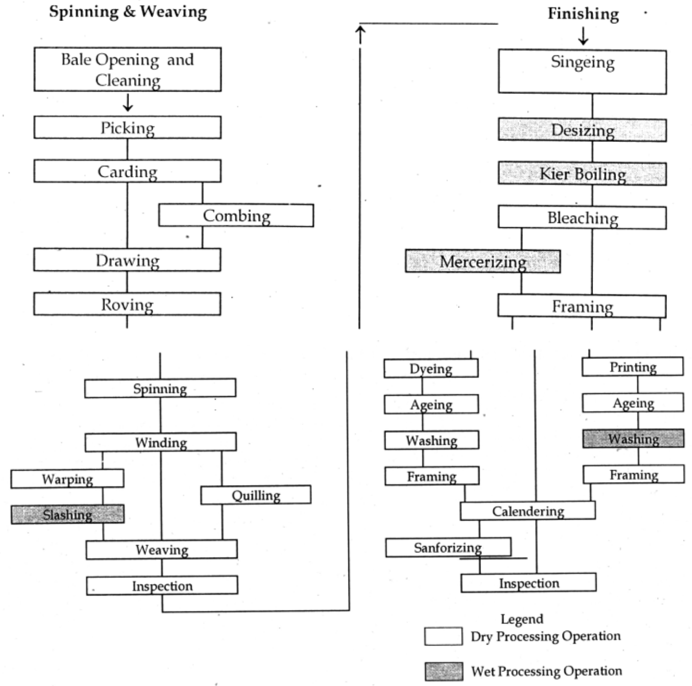


Fig. 21.4 : Cotton Processing Flowchart

5.2.2. Process Flowchart of Long Staple (i.e. Worsted Wool) Spinning :

Raw greasy wool

Sorting, selection and blending to suit type of yarn required

Opening-out and loosening of fibre packages

Scouring to remove grease and suint (sheep's dried perspiration)[1]
and carbonisation (if necessary) to remove cellulose impurities
(in lap form)

Carding

(in sliver form)

Backwashing (scouring)
(in sliver form)

Gilling
(in sliver form)

Backwashing
(in sliver form)

Gilling
(in sliver form)

Combing
(in sliver form)

Gilling
(in roving form)

Wool tops
(in roving form)

Drawing and doubling
(several stages)
(in roving form)

Spinning by flyer, cap, ring
or mule machine into
worsted yarn

(in sliver form)

Condensing
(in roving form)

Spinning on mule
machine into woollen
yarn

Fig. 21.5 : Process Flowchart of Wool spinning.

A complete flowchart of wool processing - spinning, weaving & finishing is shown below in Fig 21.6.

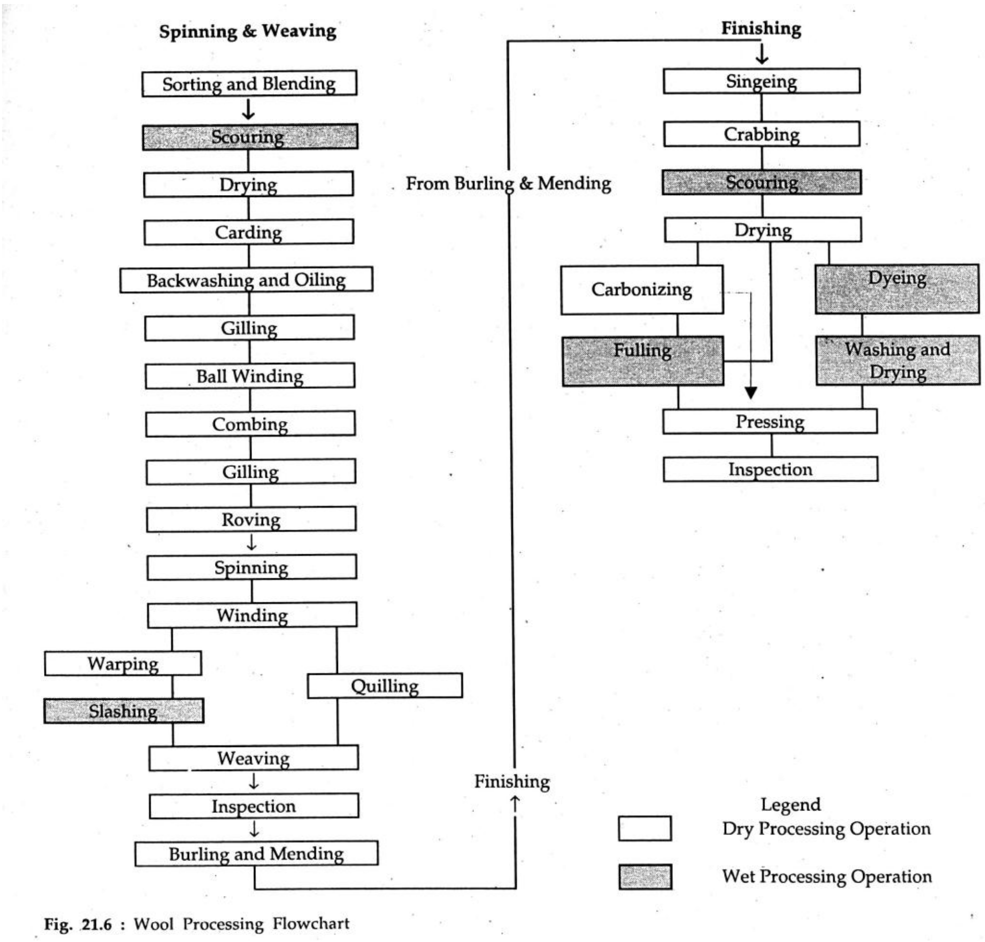
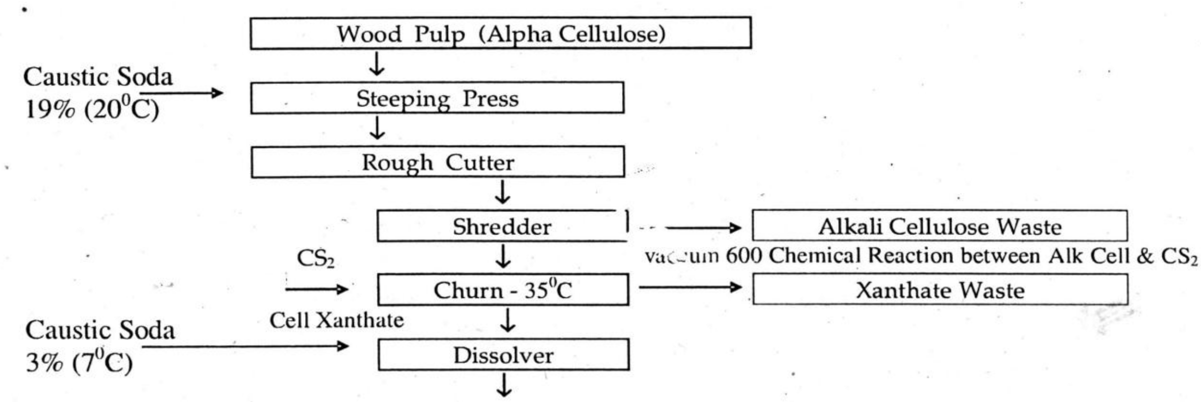


Fig. 21.6 : Wool Processing Flowchart

5.2.3. Process Flowchart of Viscose Rayon and Synthetic Fibre Manufacture :



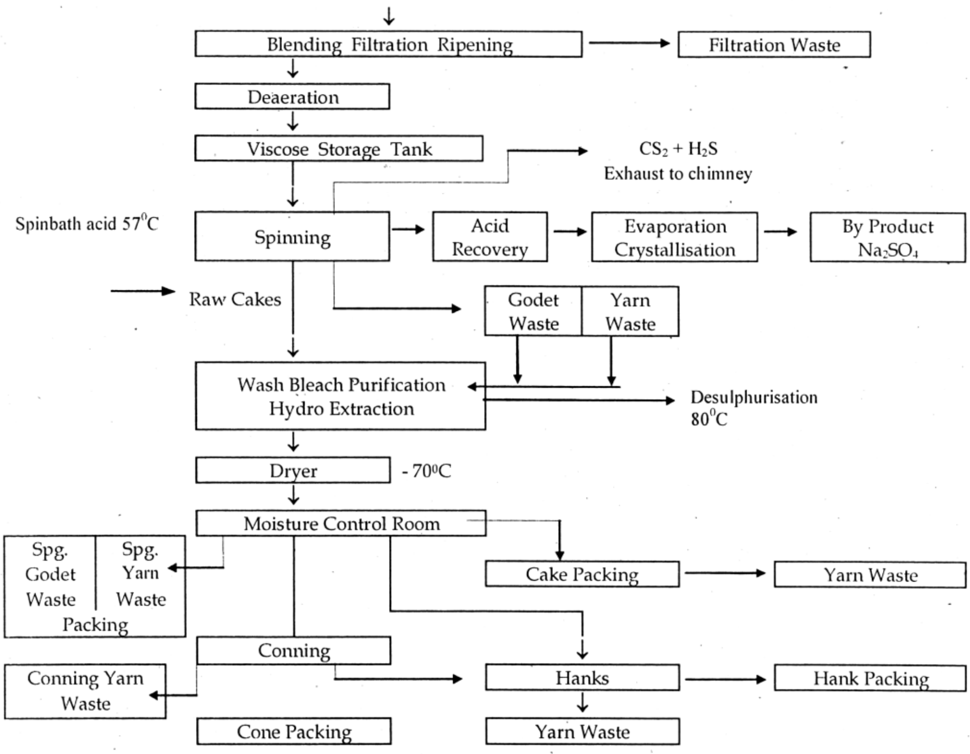
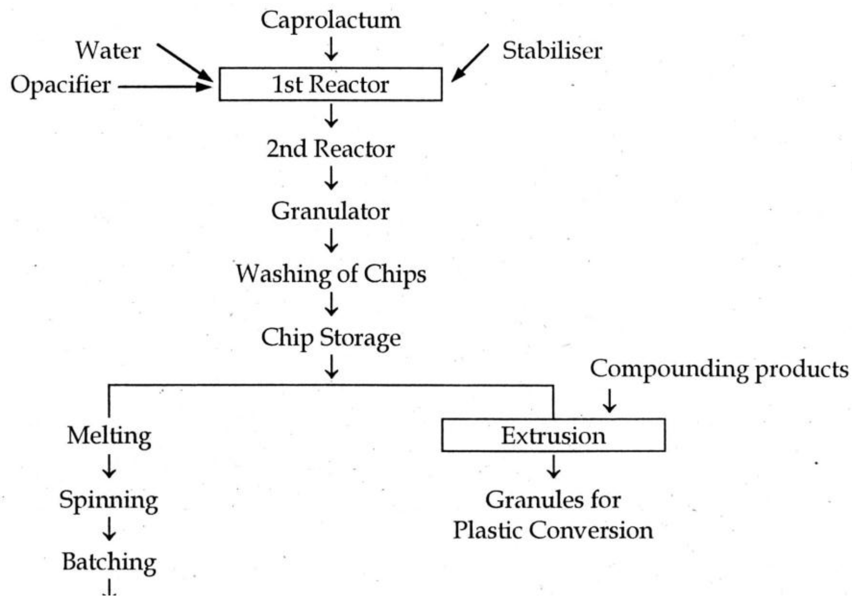


Fig. 21.7 : Process Flowchart of Viscose Rayon Manufacture

5.2.4. Process Flowchart of Spun and Filament Yarn :

(A) Manufacture of Nylon - 6.



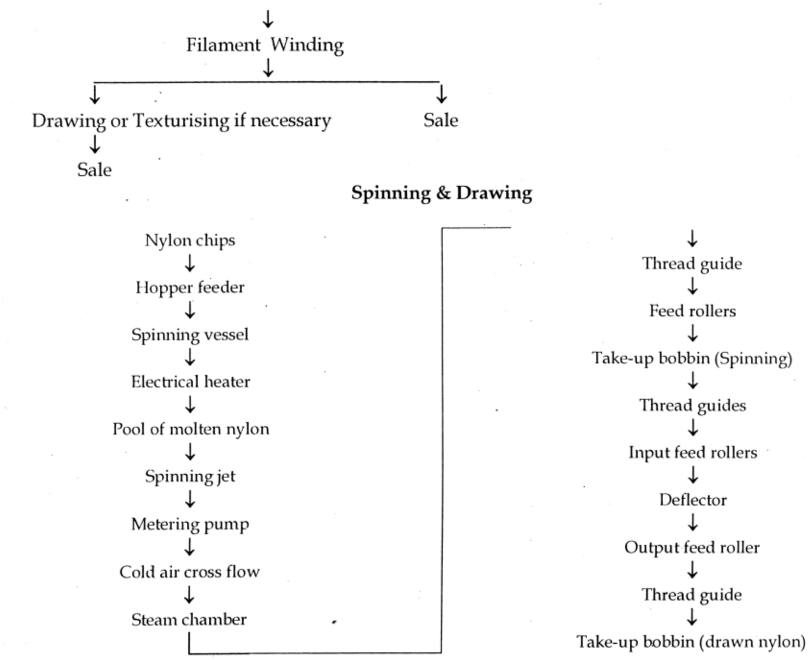


Fig 21.8 : Process Flowchart of Filament Yarn (Nylon-6)

Fig 21.8 : Process Flowchart of Filament Yarn (Nylon-6)

(B) Manufacture of Spun or Oriented Yarn (LOY, POY, HOY & FOY) :

Polyesters:

Polyesters were initially discovered and evaluated in 1929 by W.H. Carothers, who used linear aliphatic polyester materials to develop the fundamental understanding of condensation polymerisation, to study the reaction kinetics, and demonstrate that high molecular weight materials were obtainable and could be melt-spun into fibres.

Polyethylene Terephthalate (PET) is a fibre of great commercial significance, useful in cordage, apparel fabrics, industrial fabrics, conveyor belts, laminated and coated substrates, and numerous other areas. However, to engineer specific properties for special uses, many product variants have been developed and commercialised. These variants include alternative cross sections, controlling polymer molecular weight, modifying polymer composition by using co-monomers and using additive including delusterants, pigments and optical brightners.

High molecular weight polymer is used for high strength fibres in tyres, ropes, and belts. High strength and toughness are achieved by increasing the polymer molecular weight from 20000 to 30000 or higher by extended melt polymerisation or solid-phase polymerisation. Special spinning processes are required to spin the high viscosity polymer to high strength fibre. Low molecular weight fibres are weak but have a low propensity to form and retain pills, i.e. fuzz balls, which can be formed by abrasion and wear on a fabric surface. Most pill-resistant fibres are made by spinning low molecular weight fibres in combination with a melt viscosity booster.

Most of the textile fibres are delustered with 0.13.0% wt TiO, to reduce the glitter and plastic appearance. Many PET fibres also contain optical brighteners.

Manufacturing and Processing:

Terephthalic Acid (TA) or dimethyl terephthalate (DMT) reacts with ethylene glycol (EG) to form bis (2-hydroxyethyl) terephthalate [959-26-2] (BHET) which is condensation polymerised to PET with the elimination of EG. Molten polymer is extruded through a die (spinneret) forming filaments that are solidified by air cooling. Combinations of stress, strain and thermal treatments are applied to the filaments to orient and crystalize the molecular chains. These steps develop the fiber properties required for specific uses. The two general physical forms of PET fibers are continuous filament and cut staple.

Raw Materials :

For the first decade of PET manufacture, only DMT could be made sufficiently pure to produce high molecular weight PET. After about 1965, processes to purify crude TA by hydrogenation and crystallisation became commercial. In Japan, oxidation conditions are modified to give a medium purity TA suitable to manufacture PET, provided colour toners such as bluing agents or optical brighteners are added during polymerisation. Compared to DMT, advantages of TA as an ingredient are lower cost, no methanoi by-product, lower investment and energy costs, higher unit productivity, and more pure polymer because less catalyst is used. Catalysts are used in the transesterification reaction of DMT with EG and in polycondensation. Many compounds have catalytic activity. Divalent zinc and manganese are the prevalent transesterification catalysts. Antimony, titanium and germanium are the predominant polycondensation catalysts. Up to 3% delusterant is added to many PET fibre products to make them more opaque and scatter light; titanium dioxide is the most common delusterant. PET fibre blended with cotton for apparel frequently contains small amounts of fluorescent optical brighteners added during polymerisation.

Commercial production of PET polymer is a two-step process carried out through a series of continuous staged reaction vessels. First, monomer is formed by transesterification of DMT or by direct esterification of TA with EG.

In general, esterification is conducted in one or two vessels forming low molecular weight oligomers with a degree of polymerisation of about I to 7. The oligomer is pumped to one or two pre-polymerisation vessels where higher temperatures and lower pressures help remove water and EG; the degree of polymerisation increases to 15 to 20 repeat units. The temperatures are further increased and pressures decreased in the final one or two vessels to form polymer ready to spin into fibre. For most products, the final degree of polymerisation is about 70 to 100 repeat units. Average molecular weight is about 22,000; weight average molecular weight is about 44,000.

Spinning:

PET fibres are made either by directly spinning molten polymer or by melting and spinning polymer chips. A special, precise metering pump forces the molten polymer heated to about 290°C through a spinneret consisting a number of small capillaries, typically 0.2 to 0.8 mm in diameter and 0.3 to 1.5 mm long, under pressures up to 35 MPa (5000 psi). After exiting the capillary, filaments are uniformly cooled by forced convection heat transfer with laminar-flow air.

Following solidification, the threadline is passed over a finish applicator and collected. A spin finish is applied to reduce friction and eliminate static change.

It is convenient to classify commercial PET spinning processes according to the degree of molecular orientation developed in the spun fiber. Generally, the classification is a function of spinning speed. Low oriented yarn (LOY) is spun at speeds from 500 to 2500 m/min; partially oriented yarn (POY) is spun at 2500 to 4000 m/min; highly oriented yarn (HOY) is spun at 4000 to 6500 m/min; and fully oriented yarn (FOY) is spun at greater than 6500 m/min.

Drawing and Stabilisation:

Drawing is the stretching of low orientation, amorphous spun yarn {LOY) to several times their initial length. This is done to increase their orientation and tensile strength. Drawing in two or more stages is useful to optimise te'nsile properties and process continuity. Stabilisation is heating the fiber to release stress within the molecular chains melt and reform crystals and increase the level of crystallinity in order to stabilise the fibre structure.

Staple Processes:

In staple processing, the containers of combined spun ends are further combined to form a tow band and fed to a large drawline. The tow band is spread out into a flat band tracking over multiple feed and draw rolls. Crimping is the process by which two dimensional configuration and cohesive energy is imparted to synthetic fibres so they may be carded and converted to spun yarns. The tow band is cut to precise lengths using a radial multiblade cutter, normally 30 to 40 mm for blending with cotton, 50 to 100 mm for blending with wool and up to 150 mm for making carpets. Cut staple is packaged in up to 500 kg. bales at densities greater than 0.5g/ m3.

Safety and Environmental Factors :

Health & Safety : PET Fibres pose no health risk to humans or animals. Fibres have been used extensively in textiles with no adverse physiological effects from prolonged skin contact. PET has been approved by the U.S. Food and Drug Administration for food packaging and bottles. PET is considered biologically inert and has been widely used in medical inserts such as vascular implants and artificial blood vessels, artificial bone arid eye sutures.

Environmental Factors : PET materials are no dangerous to the environment and cannot contamination surface or ground water. During polymerisation, non condensible organic by-products are stripped from this process outflow streams and burned. Glycol and water are separated by refining. The water is treated in standard water spray facility. The glycol is reused The method from the DMT transesterification is refined and reused. Like all materials, polyesters should be

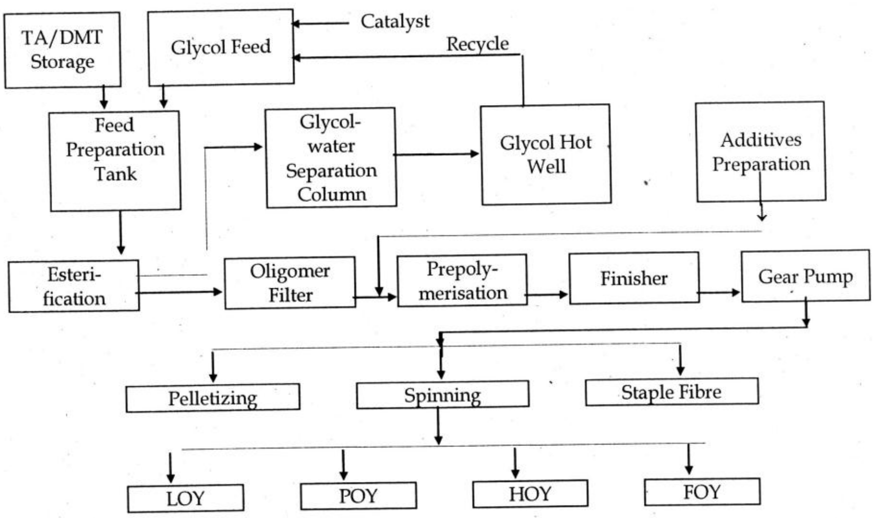


Fig 21.9 : Block Diagram for Polyester Manufacturing by Continuous Polymerisation Process

5.2.5. Jute manufacture :

The jute plant flourishes in hot and damp regions of Asia, mainly in India, Bangladesh, Pakistan, Burma and Thiland. Jute is a natural fibre and is used to make sack cloth, jute ropes, bags, camp beds, filter cloths etc.,

In 1820, jute was sent to England from India and was spun experimentally at Abingdon near Oxford. In 1822 Dundee mills in Scotland began spinning of jute. By 1850 the jute industry was well established.

In India and Bangladesh, the jute plants (Corchorus) are harvested with a hand sickle. Jute plant grows to 5 mt with a stalk diameter of 2 cm. The fibres are separated from the stem. The strands of fibre, as much as 2 mt long, are washed and hung up in the sun to dry. They are compressed into bales and sent off to the mills for spinning disposed of properly to avoid litter and can bi disposed of by landfill or incineration.

A key environmental advantage for PE" materials is the ability to recycle. Polyester materials especially bottles, can be separated from contammated materials such as aluminium caps and paper label and remanufactured by direct remelt extrusion into fibres for filling products or carpets or into layered constructions for good-grade bottles.

A block diagram of above mentioned process i «ihnwn in Pip- 21 9.

Small amount of mineral spindle oil is added into the fibre during conversion into yarn. Normal jute goods may contain upto 5% oil, but so-called 'stainless' yarns to be used for special purposes like wall coverings, cables etc., contain I % or less oil.

Jute Processes:

Raw jute is first passed through the softening machine. Oil and water emulsion is sprayed on to the jute. Sometimes sodium alkyl phosphate (Teepol) is also used. This process is known as 'batching'.

After preparation, the fibres are carded or combed, drawn and spun. Then cop and spool winding, weaving, finishing, croppong, cutting and lapping complete the processing.

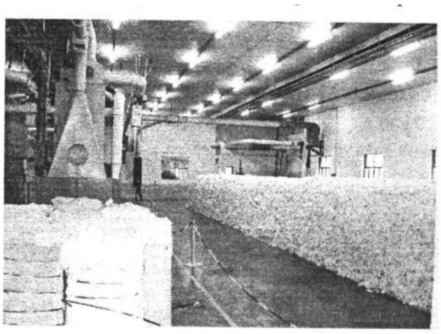
Bleaching and dyeing of jute is also possible. Dyestuffs used for cotton, are also useful for jute. The fibre has a special affinity for basic dyes, which provide brilliant effects even on unbleached base. The increased demand for rugs, mats and carpets require dyed jute yarns and fabrics suitable for these applications. Azoic and vat dyes give very bright and fast results but their high cost limits their use with jute. The tendency of jute to turn brown in sunlight is a permanent disadvantage. Hazards and Controls:

Machinery hazards are high as in case of cotton textile machinery. Main drives, gears, in-running nips of rollers or bowls, spindles and shafts, knives and cutters, flying shuttles etc. need efficient guarding. Fire may occur due to friction and heat. Water hydrants are necessary. Pesticides used in cultivation of jute may cause poisoning. Dust is given off in bale opening and spinning. Local exhaust ventilation is a must. Dermatitis gives skin trouble due to dust, batching oil, dyes etc. Excessive noise in weaving operation may cause hearing loss. Ear protection is necessary. Carrying heavy loads may cause strains. Medical examination of workers is necessary.

6 HAZARDS AND SAFETY MEASURES OF SPINNING PREPARATORY AND SPINNING PROCESSES

6.1 Opening and Blow Room Machines:

Purpose is to open cotton bales, to open and beat cotton to remove dirt/dust from it and to make it loose for the next process of spinning.



Types of machines used are :

1. Bale opener or breaker. Hard waste breaker, step cleaner. Super cleaner. Cotton opener - Porcupine or Chrighton opener. Roving waste opener. Scutcher, Combined opener and Scutcher Scutcher and Lap machine, Axi-flo, hoppel feeder etc. Tinting room is used to colour the cotton or synthetic fibres for their mixing.

2. Each machine should be driven by separate motor or by separate counter-shaft with fast and loose pulleys and efficient belt shifting device All main drives, counter drives and reductior gears shall be securely guarded.

3. All beater covers or doors giving access to any dangerous part of the machine should be interlocked or be securely fenced. Dirt door or desk door should have hinged or fixed grill as a guard and door for dirt/dust removal.

4. Dust chamber opening should be so fenced that while admitting light, prevents contact between any portion of a worker's body and the beater grid bars.

5. All belt and chain drives should be guarded.

6. In Roving waste opener, cage-wheel and side shaft wheel should be guarded.

7. In opener machine, door giving access to the nip between the lattice and the fluted guide roller of the lattice and evener rolls etc, be interlocked.

8. Inspection doors (covers) on trunkings should be properly situated and closed. If their location is dangerous, it should be changed or interlocked.

9. Spiked or fluted rollers which feed the materials from conveyors should be guarded. In-running nips of Feed and Calendar rollers must be guarded or interlocked.

10. Safe means of access i.e. catwalk, guard-rails, steps, ladders, hand-rails etc., should be provided on top of the machine where a worker has to work.

11. Lap rods - Lap stand should be proper. Lap rods should not fall out of it. Stacking of lap-rods should be proper

12. Knock-off lever - Its design or placement should be proper and the knock-off wheel should not hit a person.

13. **Unsafe actions :** The interlocks (micro-switches) on machines should not be tempered with. The supervision should he-proper for loading dead weight on a buckley opener, handling a guard, cleaning the inside of a buckley cage or bottom dust chamber collecting cotton or waste from near any revolving part, placing spiked lattice on a bale breaker, removing jam med material from rack and rack wheel, climbing the opener, feeding the lap on a scutcher and removing choked cotton through anopening in a pneumatic pipe.

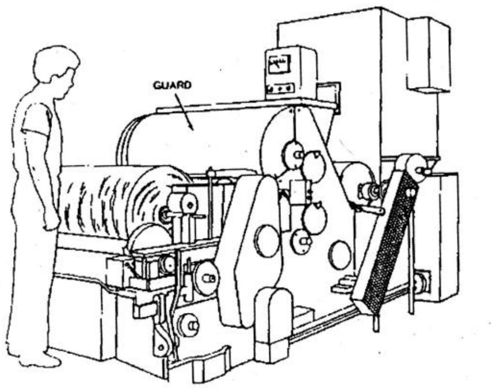
6.2 Carding Machines :

Purpose is to spin and open cotton fibres.

1. Spacing between the cards should be sufficent. All dangerous parts such as belts, ropes, pulleys, gears etc., should be securely guarded. Main drive shall be guarded.

2. The cylinder-doors must be interlocked (R. 54, Sch. 1) and effective. Stripping (cleaning cylinder) operation with open doors should be done by a trained man. The newer machines have safer stripping attachment.

3. The belt shifting devices for fast and loose pulleys should be properly maintained.



4. The nip between the plate-wheel and the side shaft wheel should be guarded.

5. **Coiler :** (i) Coiler head should not fall down (ii) Gears of the coiler box be guarded, (iii) The nip between the calendar roller wheel and the coiler back shaft wheel should be guarded or fenced.

6. **Licker-in :** (i) The access to the underside of the licker-in should be properly guarded by a hinged swing door or flap guard swinging back upwards to prevent contact while collecting dust (ii) The checking of the clearance between the licker-in and its casing while the licker-in is in motion must be prohibited (it may be done while the licker-in is stationary).

7. **Doffer & Comb Blade :** (i) Covers on doffer wheels should be closed, (ii) Work at or near the doffer cover and doffer comb blade must be done with care and properly supervised.

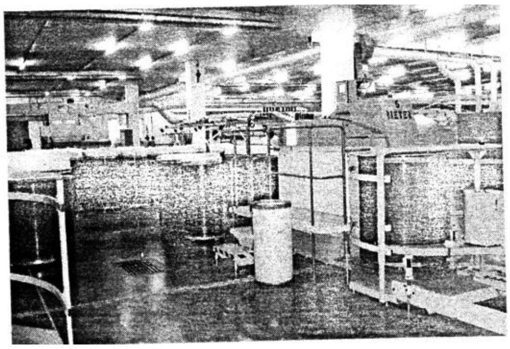
8. **High Speed Carding machine :** The in running nip between cross rolls should be securely guarded.

9. Mounting or dismounting of belt or rope and stripping and grinding operations should be done with care and should be properly supervised. It should be checked that while such stripping or grinding, the stripping brush is properly positioned so that it may not be loosened, the idler wheel and the umbrella wheel are properly fitted (so that they may not get loosed and fell down) (ii) Gauging the clearance between the flats and the card-cylinder should 130 done with the cylinder stationary (not rotated even manually) and by a standard angular gauge for this operation. It should be so supervised.

10. **Local Exhaust Ventilation :** Modern card machines have built-in local exhaust system with dust collection chamber to extract the cotton dust generating in the machine and to prevent its exposure in the work environment. This system should be efficiently maintained

6.3 Sliver and Ribbon Lap Machines:

Purpose is to make a sliver and lap from spinned cotton.



1. **Types of these machines are :** Sliver lap, lap m/c or lap-former, Derby doubler. Ribbon lap m/c etc. The main and counter drive shall be securely guarded.
2. **Nip** between the lap forming rollers (lap roller and fluted roller) should be guarded. It is desirable if it is interlocked (R. 54, Sch. 1).
3. **Ribbon lap m/c :** The lap drum and calendar drum gap should be interlocked.
4. **Sliver lap m/c :** Nip guard at the intake end of the calendar rollers necessary.
5. The carding slivers should be made parallel and combined to form a lap sheet suitable for feeding to a combing m/c.
6. **Unsafe actions :** Care must be taken during operations such as cleaning cap bars of a lap m/c, placing laps on lap rack, putting a lap rod on a lap stand, removing the chain drive from lap forming m/c, cleaning the ribbon of lap m/c and putting a lap end around a spool.

6.4 Combers and Drawing Frames :

Purpose is to comb (to make fibres parallel), pull and draw the fibres of lap of cotton.

1. Comber Machine : (i) The main drive shall have fixed guard (ii) The moving spiked cylinder should be interlocked, (iii) The cylinder covers i.e. hood of the comb near comber cylinder and the coiler covers should be fixed so as not to fall down and hit (iv) Hinged transparent guard to prevent contact with rotating segment i.e. nipper or gripper (v) Guard on top comb and detaching rolls (vi) Guard on calendar rollers and gears (vii) Interlock guard on coiler and draw-box gears.

2. **Drawing frames :** (i) Guards be provided on moving calendar rollers and gears (Nip between rollers should be covered), (ii) The gear wheels should be guarded or fenced, (iii) The head stock gearing must be guarded, (iv) The mango vacuum box of the top roller should be securely fixed, (so as not to fall down) (v) Sharp projections on the coiler bottom plate should be removed or rounded (vi) Off-end gear cover should be guarded.

6.5 Roving (Speed) Frames :

Roving means drawing of the first thread from the sliver. Purpose is drawing and twisting of fibres (thread).

1. **Types of these m/cs are :** Slubbing frames, inter frames etc. The main drive shall be securely guarded.
2. The head stock gearing (jack box wheels) should be interlocked. (R. 54, Sch I GFR).
3. **Slubber Frames :** (i) The driving bevel and bevel wheel should be guarded, (ii) The spindle shaft wheel should be guarded, (iii) Bobbin and spindle bevel gears should be guarded, (iv) The ratchet wheel should be guarded, (v) Work close to revolving flyers should be done only after stopping the flyers. It should be supervised so. (vi) Care should be exercised while handling of rollers and weights.
4. **Inter (Speed) Frames :** (i) The guard of the head stock gearing should be adequate or interlocked (ii) The stacking of bobbins on creel top should be done in safe manner, (so that the bobbins may not fall down) (iii) The height of creel top should be proper, (so as to reach easily). If not suitable, foot boards and hand holds should be provided (iv) Work close to rotating flyers should be done after stopping them (v) Draft rolls, draft gears, inter gears (jack box), cone drive and main drive should have guards.

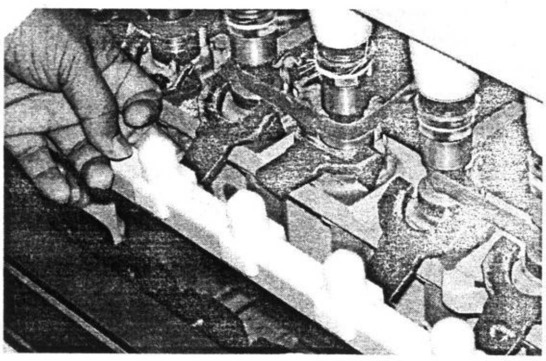
   The new open end or rotor spinning system eliminates some steps of the spinning preparatory operation and reduces many accidents.

6.6 Ring (Spinning) Frames :

Main process is twisting (rotating) and winding thread on bobbins.

Return-air system with humid air suppliers (diffusers) is used for better ventilation and humidification. Purpose of humidifiction is to prevent thread breaking. It provides large duct area through floor openings, air cleaning, rapid air changes, more humidification and more reduction in flying fluffs.

1. **Transmission parts :** (i) The main drive and the other driving belts and ropes should be guarded, (ii) Mounting of taps on jockey pulleys should be done after stopping the pulley by cutting of power, (iii) The headstock gears should be interlocked. Tieing ribbon on limitswitches and making interlocking ineffective is noticed many times. By frequent checking such unsafe practice must be discouraged, (iv) Drafting gear and drafting rollers, warm and warm wheel should be guarded.



2. **Damaged Bobbin Shields :** Sharp edges of the broken metal shields of bobbins cause many injuries on fingers while piecing or doffing operations. Following remedies should be provided, (i) Inspection and rejection of damaged shields, (ii) Use of plastic bobbins instead of wooden with metal shields, (iii) Suitable kneebrake or hand brake as

shown in the figure for each spindle to stop it. The .height of this brake should coincide with the knee of the worker. This is the design (ergonomic) aspect.

3. **Struck against various m/c parts :** (i) The sharp edge of a protruding metal sheet on the frame and broken edge of a ring frame may cause struck injury. Such damaged components should be replaced, (ii) Care should be taken while creeling, de-creeling, piecing, cleaning rollers, cleaning cotton fluff, stopping bobbins for piecing, fixing bobbins on spindles, doffing and adjusting arbor so as not to be struck against rollers, their supporting brackets or roller beams; work near lappet rail, filter-box, lappet middlerollers, top arm and cradle and middle arbor and cradle assembly, pocker rod, tube bracket and dashing against the frame of the machine while attending to different jobs. Proper supervision necessary.
4. **Fall of bobbins from creel top :** (i) Stacking of bobbins on creel top should not be haphazard. Only one row of bobbins should be stacked, (ii) Safe means of access i.e. suitable foot-boards and hand-holds should be provided for climbing up.
5. **Fall of rollers :** (i) Fall of clearer rollers and dead weight rollers occur in the course of operations such as releasing auto-lever, piecing, removing the rollers or holding them for cleaning. Care is necessary, (ii) Mechanism holding the rollers in position should be maintained in good condition.
6. **Auto-lever :** (i) Care should be taken while releasing or replacing the auto-lever, (ii) Condition of the saddle should not be defective.
7. **Ring travellers :** These can fly and injure persons unless there is an effective system of periodical replacement. Also the travellers should be of good quality and properly fitted.
8. **Dotting boxes :** (i) The hook on the doffing boxes for placing them on the rail should be proper. (ii) Splintered condition of the boxes and the protruding metal band may cause accident. Their periodical inspection and repair is necessary.
9. **Suction pipes :** Sharp or broken edge of a suction pipe may cause injury. It should be checked and required or replaced. Suction fan with duct is provided to collect broken ends.
10. **Others :** (i) Side plate of a frame may get loose and fall down. It should be periodically inspected, (ii) All motor fans should be closed by the covers.

6.7 Doubling Machines (frames) :

Two or more threads are joined, twisted and wound on bobbin.

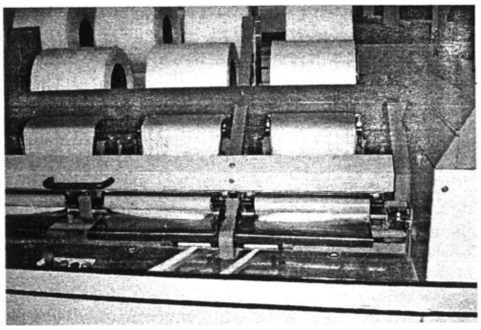
1. **Drives :** Main drive pulley belt and head stock gearing should have guards. Delivery roll gears should be guarded.
2. **Knee-brakes :** They should be provided to stop bobbin for piecing operation and maintained properly. They should be at proper knee height.
3. **Cans :** (i) The edges of cans for storing bobbins should not be broken or sharp, (ii) They should be inspected and repaired or replaced, (iii) Plastic cans are desirable.
4. **Ring Travellers :** (i) They should be of good quality and properly fitted, (ii) They should be periodically inspected and replaced.
5. **Machine Parts :** The creel tops to store bobbins should be within the arms reach. Foot rails should be provided.
6. **Unsafe actions :** Striking against knee-brakes, ring travellers, top roller, tap on a spindle, rough edge of jockey pulley etc., may cause accidents. Care should be exercised and supervised.

7 HAZARDS AND SAFETY MEASURES OF WEAVING PREPARATORY AND WEAVING PROCESSES

7.1 Winding Machines :

Purpose is to wind weft on bobbins.

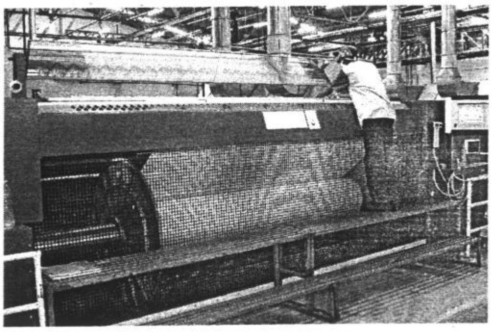
Types of machines used are : Barber-Coleman ITI/C, Auto-coner, pirn winder etc.



1. Guards should be provided on main drive, revolving drum, drum drive motor, timer drive, cam drive, traveller pulley and track nip and conveyor drive. Knotter-carriage assembly & spindle assembly should have cover.
2. The gap between the moving parts of conveyor and fixed parts should be checked all along its length and reduced to the minimum by suitable covers/guards.
3. Bobbins/sleeves used on the m/cs should be inspected for broken edges, burrs etc. as also for their proper fitment on driving spindles.
4. Haste in loading spindles with empty bobbins should be avoided. Also, dust and other extraneous materials on spindle and moving yarn should not be removed while they are in motion. Dust collecting blower and bag are useful.
5. Automatic winders like cone winder and spoolers prevent hands reaching near the rotating drum and are preferable.

7.2 Warping Machines :

Purpose is to wind warp on warp beam. Different types of warping m/cs are available.



1. The flanges of rotating beam should be properly guarded. Aluminium flange beam without metal flange ring is safer. Metal flange ring may open, fly out and hit.
2. The main drive, gear wheels, motor pulley, clutch pulley-belt and other parts should be properly guarded.
3. The nip between the driving roll and warp beam should be guarded. Trip cum distance guard should be provided for protection from rotating beam.
4. Beam side distance guard (rod) should be interlocked (contact switch) with drum which drives the beam-.

5. Multiple photo-electric device is more safe.
6. Hydraulic braking system should be provided to stop the beam within shortest possible time.
7. Stop motion indicator lamp is useful.
8. Wheels of moveable stands should have guards.
9. Drum drive motor pulley, beam drive chain, beam ends and section warping gears should be guarded.
10. **Unsafe actions :** Dashing against rotating beam, leading the thread from the creel to the drum (at this time the m/c should be stopped), removing ball bearing from the shaft of the warp roll, stepping on the slopping platforms of the m/c, removing empty pegs from bobbins on creels and loading and unloading the beams can cause injuries.

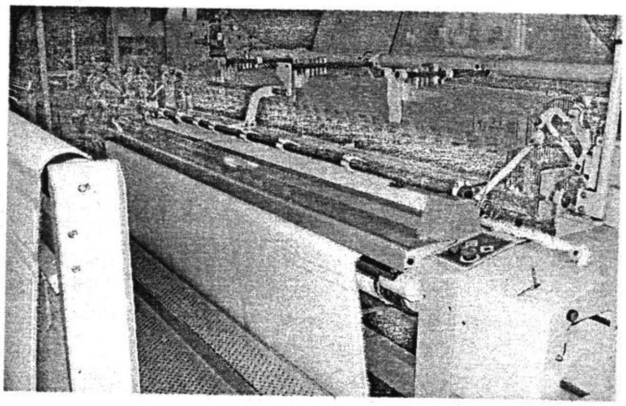
7.3 Sizing Machines :

Purpose is to apply starch on yarn or cloth.

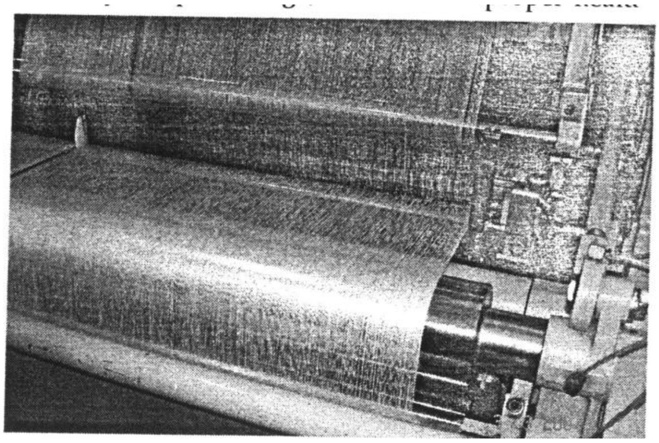
1. Nips : Nip guards should be provided on in running nips between the driving rolls and other revolving rolls at the front of the m/c. Guards on drag rolls and squeeze rolls are essential.
2. The main drive, beam drive chain, size box drive chain and speedometer chain should be guarded.
3. Suction hood necessary to arrest steam vapour.
4. **Gears :** The gears of the marking mechanism of the m/c should be guarded. Other m/c parts be guarded.
5. **Beam weights :** The counter weights of a beam should be properly placed so that they may not fall down while touching.
6. Loading and unloading of beams can cause accidents. Care should be exercised.
7. **Rule 61(8) GFR :** (i) These provisions should be followed for thin wall cylinders, (ii) Form No. 11- test report - should be available for each sizing cylinder, (iii) Pressure reducing valve, safety valve, pressure gauge, steam trap and drain-cock for condenset, steam stop valve etc., should be properly provided, set and maintained for ensuring safety, (iv) Maximum permissible working pressure shall be reduced 5% every year (v) Maximum life 20 years. (vi) New and second hand pressure vessel shall be tested at 1.5 times 'its Maximum Permissible Working Pressure.

7.4 Looms (power looms) :

Purpose is to weave cloth by using weft (pirn) bobbins and warp beam by a machine known as loom.



1. **Types of looms are :** Ordinary power looms, automated jacquard looms, drop-box, dobby, air-jet, water-jet, rapier etc. Loom sizes are 46", 52", 56", 60" and 64".
2. **Flying Shuttles :** (i) Shuttle flight may be caused by warp breakage, broken or improper heald



(heddle) wires, slackness in picking mechanism and other causes. Shuttle less looms (auto looms) is the best remedy for shuttle flights, but it is not economical. Therefore, the practical remedy is the shuttle guard. The shuttle guards be properly provided. It should extent sufficiently forward and the gap below it should not be too much. Because of possibility of change in this gap and despite the guard the shuttle car fly and hit Certainly they protect the upper body of a worker from hitting, (ii) To protect from injury due to shuttle flying from the adjacent loom, every loom must be equipped with barrier guard placed close to each end of the slay beam Such guards of strong wire netting or similar material are advisable, (iii) Reasons for shuttle flights should be properly recorded, investigated and removed.

3. **Shuttles :** (i) Shuttle receptacle should be provided near each end of the slay to place the shuttle properly, (ii) Removing empty pirn (bobbin in shuttle) 'and loading wound pirn into the shuttle may cause injury. Also care should be exercised while placing shuttle on the slay. (iii) Automation of process of filling up the empty shuttle can reduce these hazards where a pirn battery loads the shuttle as soon as the weft yarn on it is exhausted. This device of modern looms is advisable.

4. **Picking stick assembly :** (i) Vertical picking stick is less dangerous than horizontal one. Work near the proximity of the stick should be done carefully, (ii) Spacing between two looms should be at least 55 cm measured from the farthest projecting point of an adjacent loom or wall. The aisles (alleys) should atleast be one meter wide. It is so desirable for safe movement, (iii) Picking stick (arm) should be securely guarded along its fixed path of movement so that hitting by it can be avoided, (iv) The loom spindle on which the picker moves may crack or fly out and hit. Defective spindle should be found out and replaced, (v) Picking spring should be inserted in position carefully (vi) The picking wheel should be guarded, (vii) All parts of picking mechanism and heald frame should be sound for proper fitment, wear and tear.

5. **Beam Weighing :** (i) Compound lever should be adopted for beam weighing wherever possible. The shape of the weights should be such that they would not come off the lever and hit. Weights of shape '8' should be preferred to those of shape 'C'. Weights must be harnessed to the beam by strings or straps of adequate strength (ii) Spring loaded mechanism used for beam weighing should be inspected at least once in a week and defects, if any, rectified. Defects of spring, lever handle, threads used if any, should be found and removed.

6. **Cloth and Emery rolls :** (i) The support brackets of the cloth roll should be examined once a week for any defects to ensure that the cloth roll sits tight in the brackets, (ii) Care should be taken from hitting the cloth or emery rolls while walking near them (iii) Heavy cloth rolls should be handled mechanically or by more workers, (iv) Guards should be provided on emery roll and

guide roll, crank tappet gears, take-up gears, bottom cam drive gears, motor drive, shedding motion etc.

7. **Slay beam :** (i) The slay moving towards and away from the weaver may hit the hand and fingers may get trapped between the moving slay and the front rest head frame, temples etc. Hands should not be placed on the slay or at places near its path. (ii) Clearance between the slay bolts of two adjacent looms should be adequate, (iii) Setting of die weft fork holder and hammer should be proper, (iv) Removing fluff or wastes and attending to minor adjustment on the loom must be done only after stopping the loom.

8. **Duck bill and Hitter :** The duck bill and hitter should be guarded on every loom to prevent contact with sharp edges of these moving parts or being trapped between them. Such guards can be in the form of close pitched springs surrounding the duck bill and extending 3 to 5 cm beyond so that approach to the sharp edges from the sides is prevented.

9. **Others :** (i) Driving pulley-belts (main drive) of the loom must be securely guarded by a fixed guard. (ii) Ratchet and pawl or crank and tappet mechanism (including gears) should be guarded. The edges of the guards should not be sharp so that it may injure, (iii) The tuning of the loom should be checked once in every shift and adjusted wherever necessary (iv) Spare pirns and their boxes should be examined for their broken edges etc., and should be rectified, (v) The operators must be alert to join the broken ends. They should be joined only after stopping the loom. (vi) Pall of various improperly fitted loom parts on workers while cleaning, oiling etc., dashing against loom parts, getting caught between loom parts due to accidental starting, striking weft box while loading or unloading pirns, striking heald wire while drawing ends or doing adjustments nearby etc., may cause accidents. Care should be exercised and supervised in such operations, (vii) Suction device for pirn-battery return air system, diffusers, sprinklers, hydrants, fire extinguishers etc. should be in good working order.

10. **Noise :** Hearing loss is possible due to high noise in loom shed. Noise level should be below 90 dBA. Shuttle less loom gives less noise. Good lubrication and maintenance, proper tuning, quick replacement of damaged parts of picking mechanism and stroke resistors help to reduce noise. Workers should wear ear protection.

8. HAZARDS AND SAFETY MEASURES OF PROCESSING (FINISHING) AND FOLDING MACHINES

8.1 General Precautions :

1. **Types of machines in use are :** Shearing, singing, washing, bleaching, kiers, yarn and cloth dyeing, printing, polymerising, sanforising, stentering, padding, finishing, folding, bale (cloth) pressing machine etc.
2. The in-running nips between rollers and similar parts, unless the nips are inaccessible, should be securely guarded with nip guards (bars) along the whole length on the intake side (Rule 54, Sch II, GFR).
3. In dryers and similar machines where there is a risk of access from the sides to nips referred to in item (2) above and driving gears should-be guarded to prevent such access.
4. Other machine parts such as main and counter drive, belts, pulleys, shafts, gears and flappers should be guarded.
5. Removing crease from die cloth on rollers should never be done when the machine is in motion.

6. Oiling, greasing, adjustment or repairing near dangerous parts should not be done with the machine running.
7. Entanglement with the cloth in process is a serious hazard in some of die machines. While working here, care should be exercised and supervised.
8. To the extent possible, splash guards should be provided for containing the likely splashes of chemicals and hot liquids at those parts of machine where- splashes generally occur. These would also facilitate keeping the floor free from spillage.
9. Wherever risk of splashes from chemical or hot solutions exists, operators should be provided with PPE such as face shields or goggles, hand gloves, aprons and gum-boots.
10. Wherever persons have to reach and work at parts of machine situated at heights, suitable means of access in the form of catwalks and platforms should be provided. Wherever these are not provided due to infrequency of the operations or any other reason, alternative arrangements such as scaffolding or safe ladder should be provided and the operations carried out confirming to standard safe practices.
11. Dismantling and fitting of heavy parts of machine should be done with care. To the extent possible, mechanical handling devices should be used for the purpose.
12. Acids, alkalis, bleach liquors or whitening agents, dyestuffs and solvents are used for process or cleaning purpose. Their storage should be kept away in a separate room. They should be handled in small containers with lids. Their spillage or leakage should be avoided and cleaned immediately. Cleaning by solvent is risky. Source of ignition must be avoided while using solvent to clean printing machine, vessel, container etc. Then nearby electric fitting should be flameproof or switched off. Ordinary short circuit has caused many accidents.

Schedule 12 and .19 u/r 102, GFR should be followed while handling acids, alkalis and other chemicals. Rule 68D should be followed for using hot oil circulation in stenter etc. through thermic fluid heaters.

8.2 Bleaching Process :

Purpose is to whiten the cloth or yarn (threads). Normally chlorine, sodium hypochlorite or hydrogen peroxide are used as bleach liquors. Their concentration should be within safe limits. They should be stored in minimum quantities. Transfer from bulk storage to small containers should be safe. Flexible connections must be checked for safety. Emergency kit to handle chlorine leak should be kept ready. Proper respirator, eye goggles and gloves should be worn while working near chlorine gas or hydrogen peroxide fumes. Addition of chlorine in caustic solution to make sodium hypochlorite should be in closed and safe system. See Part 8.6.1 of Chapter-18 for chlorine safety.

Open bleaching tanks should have fencing to prevent fall inside.

Bleaching machine should have fume exhaust device. Bleaching range should have nip guard on rolls.

8.3 Processing Machines (Dyeing, Printing etc) :

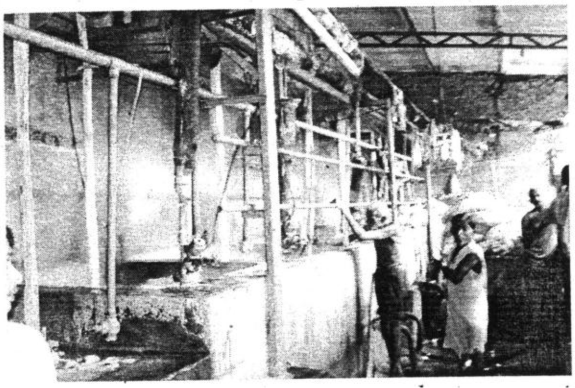
Purpose is to wash, dye (colour), print, dry, heat, press, stretch, carbonise, mercerise, sunforise and fold the cloth etc.

Water is used in large quantities in processing machines. Reverse Osmosis (RO) Plant should be used to remove hardness as well as total dissolved solids (TDS) if the water available is hard and saline (salty). Such soft and salt less water decreases rate of corrosion and increases life of the vessels/ machines.

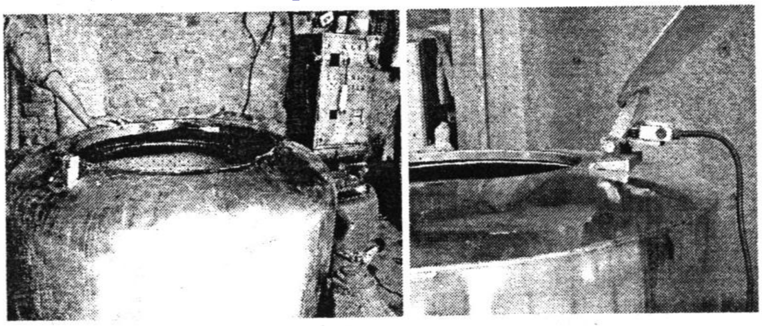
Safety measures for some processing machines are stated below.

1. **Washing machine :** Purpose is to wash the cloth in open tub (i.e. no pressure) (i) Nip Guards on rollers (ii) Catwalk and platforms to reach and work at the required places with sufficient handhold and foothold (iii) Guard on moving flappers, (iv) Distance guard, belt and chain guard (v) FRP and acid-proof lining if acid/alkali is used. (vi) Clean overflow "pipe with water tank (vii) Nip guard on draw nip (viii) Air regulator for pneumatic loading of rolls (ix) Guards on chain drives of nip rolls (x) Doors on soap tanks (xi) safely of steam lines and (xii) Guard on chain drive of a plaiter. (xiii) Nif guard on padding mangle.

2. **Washing Tanks :** Purpose is to wash the cloth (i) Railing near hot water tanks to prevent falling into it (ii) Drain pipes and valves to drain hot water from the tank. Simple hole, cotton plug (stopper) and bamboo use is an unsafe practice.



3. **Hydroextractor :** Purpose is to remove water from wet cloth, (i) Interlock basket cover (ii) Fixed guard on pulley-belts (iii) Brake to stop basket.



(a) (b)

Hydro extractor - (a) Hazard due to no basket cover (b) Basket cover with electrical enterlocking.

4. **Jigger machine :** Purpose is to colour the cloth in open tub (i.e. no pressure), (i) Nip guards on rollers and gears (ii) Splash guards should be provided on each of such machines to minimise chances of chemicals and colour solutions splashing on persons, (iii) Aprons and chemical goggles should be given to workers (iv) Periodic inspection and maintenance of the floors. They should be free from water and solution so as not to keep it slippery, (v) Pneumatic valve to control steani flow (vi) Cover on motor pulley belt drive and gearbox (vi) Roll motion controller.

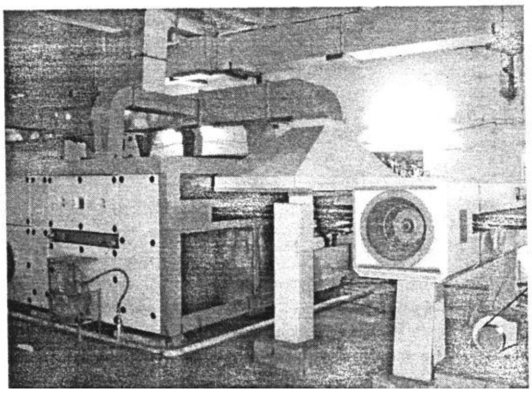
5. **Calendar machine :** Its function is to give fine finish (ironing) by passing the cloth through calendar rolls or bowls, (i) Auto temperature control to prevent over heating (ii) Nip guards on in-running nips (iii) Guards on main motor drive and reduction gears, (iv) Heavy rolls should be handled mechanically (v) Contact with hot rolls may cause burn injury. Care should be taken

while working at heights (vi) When steam pressure is above atmospheric pressure. Rule 61 GFR should be complied with. All safety devices should be properly maintained.

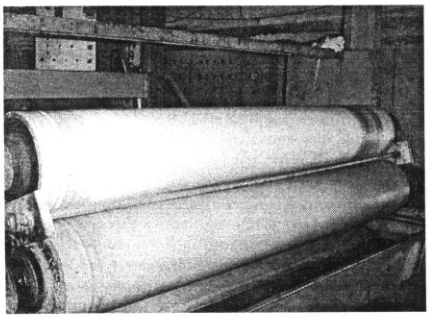
6. **Drying machines :** Purpose is to dry cloth, (i) Nip guards on rotating rolls and mangle rolls. Guards on chain, bevel gears, winch drive and stack drive, (ii) Platform, foothold and handhold to work at heights (iii) Hot cylinders of drying range may cause burn injury. Care and effective supervision (iv) For pressure control, follow Rule 61, GFR.

7. **Kiers and Agers :** Purpose is heating by steam pressure, (i) While tightening the eye bolts of kier, bars used should be of such construction that they hold the eye bolt securely and do not slip off. (ii) Catwalks and platforms to work on the top of the Kier (iii) Care form coming into contact with the hot parts of the kier (iv) Pressure reducing valve, safety valve, pressure gauge, stop valve etc. should be properly maintained for the safe working pressure inside. Safety valve and pressure gauge should be provided on jacket also (v) Hydraulic pressure test at every two years (vi) Chain pulley block or hoist to lift heavy parts.

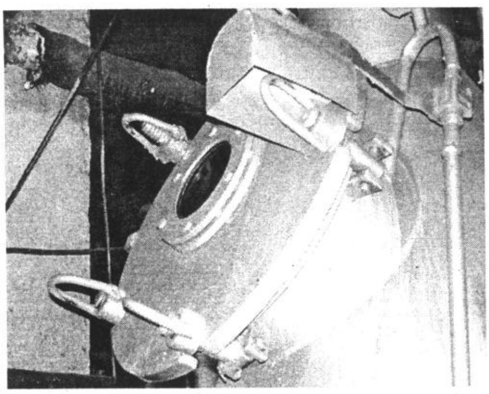
8. **Stenter machine :** Purpose is to dry cloth by passing it through heat chambers. Padding mangle, feeding zone, heating zone (chambers), batching and plaiting are main divisions (i) Nip guard between in-running rolls and rollers of the padding mangle, guard on uncurler nip, main drive and bevel gears (ii) Catwalks or platforms for working at heights, (iii) Temperature control devices (iv) Effective exhaust hood and chimney for removal of fumes from the machine, (v) Effective and sufficient exhaust fans in the workroom (vi) Scouring process i.e. oil removal from fabric before feeding it to the stenter machine to reduce the oil fumes, (vii) Textometer to detect moisture content, (viii) Covers on roll drive chain box, overfeed chain drive, batching and plaiter drive (ix) 3-way pneumatic oil flow control valve where oil heaters are used.



9. **Pladding machine :** (i) Nip guard on in-running rolls and padding mangle (ii) Guard on main drive, roll chain drive and gear drive (iii) Pressure regulator for pneumatic loading of rolls. drive, roll chain drive and gear drive, (iii) Pressure regulator for pneumatic loading of rolls.

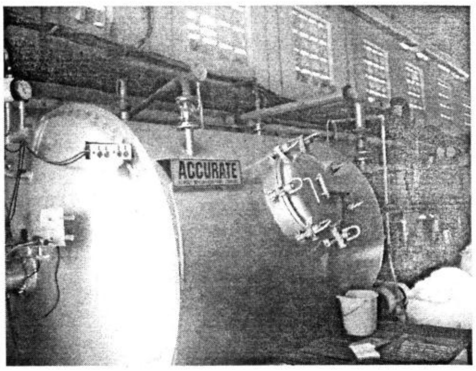


10. **Jet Dyeing machines -.**Purpose is to colour the cloth under steam pressure, (i) PRV or pressure regulator in pressure feed line (ii) Adequate safety valve and rupture disc - both of at least .1.5 inch (dia) size and in parallel on the top of the vapour cell (iii) High pressure alarm and automatic or manual de-pressure (venting) device to operate at that alarm (iv) Use of heatexchanger for indirect heating and cooling (v) Periodical hydraulic tests and NDT for corrosion effects



(vi) Non-corrosive metal, joints and body parts (vii) Flap guard near filter cover at the bottom and internal disc to restrict outflow (viii) Temperature gauge near the pressure gauge on the vessel (ix) Water, steam and air control valves (x) Manhole cover interlocked with depressure device (xi) Maximum pressure indicator and automatic pressure controller (xii) Trained operator (xiii) Effective supervision and auto programming.

11. **Drum washer :** It is a washing machine under steam pressure, (i) Fixed guards on belt and chain drive (ii) Pressure Reducing Valve, Safety Valve, rupture disc, proper nut bolts and fitting or welding, proper material of construction and Pressure Gauge on steam supply line (iii) Drum motion fixing device (locking) while loading and unloading. Internal drum should not rotate while loading or unloading it. It should be mechanically locked. Power should also be deenergised at that time.



12. **Expander machine :** (i) Nip guard on rollers and between the cloth in process and the rollers (ii) Parts of machine should be periodically examined to detect defective conditions such as protruding nails.

13. **Stitching and sewing machine :** (i) Gap between the needle and the machine table should be guarded to 'prevent access to this zone. (ii) Electric earthing should be proper and ELCB should be provided in power supply line.

14. **Printing machine :** Purpose is to print the cloth by machine. Various types of machines are in use. (i) Nip guards on the printing roller, cloth roller and on the lapping and a roller (ii) While removing a heavy roll from the machine, care should be taken' or the mechanical handling should be used. (iii) Care should be exercised while changing a design roller otherwise a hand may be caught between the design roller and control roller (iv) Care should be taken while turning a handle to apply pressure to the printing rollers otherwise a worker may slip and fall from height (v) The doctor blade of the machine should be removed carefully otherwise it may slip and its sharp edge may cause injury. (vi) Fixed guards on pulley-belt drive, sector, connecting (eccentric) rod, repeat-setting device and under table rollers (vi) Safety while cleaning blanket.

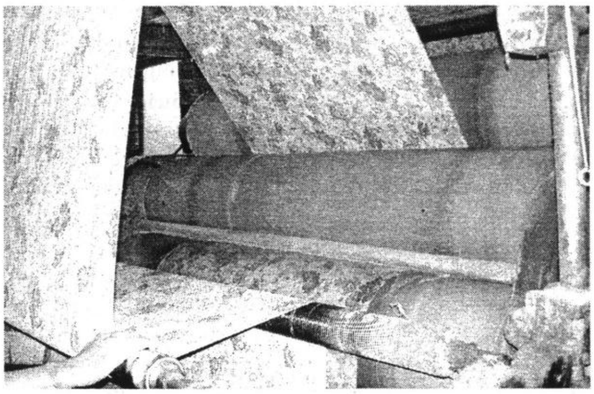
15. **Stretching machine :** Nip guard between running cloth and roller.

16. **Polymerising or curing machine :** See part 3.3 and 9 of this Chapter.

17. **Gas/Electrical Singeing machine :** See part 9 of this Chapter.

18. **Shearing and Cropping machine :** (i) Rotating cutters should be interlocked by a transparent cover, (ii) Guards on main drive, suction blower and dust chamber and (iii) Metal detector are necessary.

19. Sanforizing and Palmer machine : Its function is to give final finish (ironing) to the cloth.



(i) Nip guards and side guards on in-running rolls and trip wire near cylinder (height < 1.7 mt) to stop the motion (ii) Pneumatic controls and roll drives guards (iii) Steamline safety (iv) Plaiter drive guard.

20. Mercerising machine : Nip guard on mangle rolls, guards on main drive coupling, chain drive, bevel gears, mangle roll gears, chain return wheel, squeeze roll belt drive, squeeze rolls, impregnator nip between float roll and top roll, stabilizer-tension roll and top roll nip and splash guard on caustic tank are necessary.

21. Carbonising unit : Its function is carbonising i.e. acid burning of cotton fibre of the blended cloth. (i) Acid bath (70% H,SO,,) should have safe overflow device and splash, guards on both sides (ii) Nip guard on squeeze rolls (iii) FRP tray and acid-proof flooring, PVC valves for acid use and use of PPE and safety shower by workers.

22. Folding machine : (i) The crank-wheel and reciprocating arm should be guarded to prevent hit injury, (ii) Fixed guard on main drive.

23. Towel cutting machine : Cutting edge should be guarded at the feeding end of towel.

In addition to above textile machine guarding, general safety measures for metal working machinery, lifting machines, material handling, hand tools, hand trucks, chemicals, flooring, fire and health hazards, must also be provided and maintained. Welfare facilities of canteens, lunch/rest room, ambulance room, creche, welfare and safety officers should also be provided. See Part-3 for statutory provisions.

9 FIRE AND EXPLOSION HAZARDS AND CONTROLS

A booklet 'Fire Prevention in Textile Industry, Instructions for Supervisors' published by the Loss Prevention Association of India Ltd., Mumbai - I (Gujarati copy is also available), IS:3079 and 2190 are most useful to understand and control fire/ explosion hazards in textile industry.

Cotton dust is not fine enough to cause dustexplosion but it may certainly cause fire if any spark is available. Explosion hazard lies with polymerising or curing machine where flammable liquids are used and therefore explosion relief are required. Fire hazard is more in blow-room and spinning sections due to loose and flying cotton and in processing department due to solvents and, chemicals.

The main cause of fire in textile mills can be attributed to the failure of electrical equipment, sparks from foreign material carried along with cotton stock, friction, hot bearings due to inadequate oiling and attention, presence of excessive quantities of fly and dust in the department and the use of flammable liquids and processing of cloth at high temperatures.

Building Construction : Textile mill buildings are classified as 'fireproof; 'non-fire proof and 'inferior'. In order to minimise the risk of fire, all mill processes and storage buildings must be of fire proof construction of at least 6 hours grading. The behaviour of a structure when subject to fire stresses must be taken into account at the design stage.

Godowns for cotton and finished products shall be essentially single storey structures and located at least 30 mt away from the spinning department. In textile mills, the departments that requires separation by perfect party walls in order to reduce the fire loads are : (a) Baled cotton warehouses, cotton mixing and blowing rooms; willow and thread extractor rooms; waste opening rooms; carding rooms; speed and ring frames; mule spinning department; preparatory sections and loom sheds, cloth processing houses with fire walls around special hazard processes such as 'singeing' and 'cloth raising', (b) Boiler houses and firing places must be separated from all process and store buildings except the engine rooms and the like. (c) Electric generating stations and transformer houses must be cited at least 10 mt away.

Cotton and yarn drying chambers must be constructed of incombustible materials and .fitted with thermostat controls in order to cut off the source of heat supply at predetermined temperatures.

Warehouses and Stores : (a) Breakage of cotton bale hoops causes sparks and subsequent fires (b) Faulty electrical equipment, both for lighting and bale stackers may cause fire; (c) Lots of baled cotton must be stacked in an orderly manner away from godown walls to prevent spread of fire arid assist fire fighting and salvage operations, (d) Adequate drainage of godown floors is necessary in order to prevent excessive water damage of lower layers.

All sources of ignition like mechanical sparks due to friction, electrical spark, spark from welding or cutting, prismatic effect of sunrays from glass window on cotton bales, use of naked flames, heated lamp or metal parts, oil dripping and electrical loose wiring or electrically heated metal parts, should be avoided by prompt supervision. Fire hydrants should be kept nearby.

Cotton Mixing and Blow Rooms : (a) Generation of sparks from foreign matters, particularly pieces of metal carried along with cotton stock through metal rollers and spiked lattices of opening and blowing lines. Loose rivets and short ends of hoop iron are the main causes which could be eliminated by providing suitable magnetic separators which should be cleaned during each shift, (b) Machines with high speeds are more prone to fires. Machines with higher capacities are exposed to large quantities of loose cotton and hence fires in such machines are carried faster and at longer distances (c) All cotton opening and cleaning machines with spiked lattices and rollers must be sprinkled.

Carding Department : Cotton in the carding machines being still in the loose stage is susceptible to fire due to friction between metallic parts, particularly fillets, licker-ins and grinds.

Spinning Frames : (a) Frequent fires occur due to heated spindle bearings of those of the rollers driving them (b) Lint and fly cleaner units of spinning frames cause fire due to improper conductor or collector shoe contacts with the open bus bars running the entire length of the machines. The uneven contacts of the collector shoes cause sparking which ignite the fluff collected around the buses, (c) Generation of static electricity is generally encountered in the spinning of rayon yarn particularly in the card room and it is safer to ground all machines and to provide suitable humidification system to eliminate static charges.

Loom Shed : The picking mechanism usually gets jammed due to accumulation of fluff which causes fire spreading and droppings below the loom or at times to the warp beams.

Processing Department:

1. **Cloth and Yarn Singeing (burning by fuel fire):** Due to the presence of open flames and flammable gases, fires are frequent in singeing rooms but these could be avoided by the use of proper electrical equipment and electrical interlocked sequence in order to prevent the machine being started up before the exhaust and gas blower fans are brought into operation. All control gear in such case must be mounted externally with vapour-proof lighting fixtures.

   Solenoid valve on the fuel line is essential to stop fuel supply in the event of power or m/c failure. This will prevent stationary fabric undergoing singeing and from being ignited.

   LPG and air pipelines should be colour coded. NRV to prevent flash back, gas burner control, no smoking notice and ready fire extinguishers are required. LPG safety rules should be followed.

   Fuel (petrol) control valve on carburettor (petrol vaporiser), temperature control on air heater, suction hood, duct and dust chamber, flameproof electric fitting, guards on nip rolls and batch drive, brush rolls and roll drive, water cooling of the guide rolls near burner and safety ladder to fuel tank are also important.

2. **Electrically heated Yarn Singeing Machines :** An interlocking arrangement is necessary to ensure that the heating elements cannot be switched on while the yarn is stationary in the machine. Only water washed fabric should pass. Solvent may cause hazard.

3. **Polymerising or Curing Machines :** Its function is to dry (by heating) the printed cloth. Several explosions and fires have occurred in polymerising machines in textile mills due to the mixture of organic solvents in the printing pigments.

   Precautions to eliminate accidents are : (1) Predrying of printed fabric over drying ranges to remove most of the solvent outside the machine. (2) Lock the exhaust openings in top of curing machine at least 2/3 full opening. (3) Electric heaters must be provided with thermostat controls and synchronised with the exhaust fan and machine main drive so that in the event of accidental failure of exhaust fan motor, the entire machine stops along with the heating elements. (4) Provision of safety flaps on the tops of polymerising machines which would open out automatically in case of explosion. (5) Air circulation fan filter gauze must be regularly cleaned as poor circulation would cause localised pockets of solvent vapour. (6) Exhaust duct must be regularly cleaned every week and extended outside the work room. (7) Interlocking of exhaust fan with fabric motion so that the fans will start before fabric is fed into the chamber.

   See Part 3.3 for Rule 68C GFR.

   Steam curing is safer.

4. **Cloth Raising Department :** Here fires are frequent due to passage of foreign materials between filleted rollers and it is necessary that the cloth be inspected before passing through the machine. The machine must be regularly cleaned of fluff accumulation.

5. **Electrical Installation:** Electrical equipment must comply with Electricity Act and Rules (See Part 2 of Chapter-28), relevant Indian Standards and installed and maintained in safe condition. Lighting fixtures in places where considerable dust and fluff accumulate and godowns must be of dust-proof type, wired in screwed conduits and switchgear must be mounted externally. Stop motion devices on machines must be dust-proof, wired in conduit and checked regularly. Overhead electric lines in compounds should also be cleaned regularly.

6. **Fire Extinguishers:**

   Fire fighting arrangements consisting of portable appliances, water hydrants and automatic sprinklers must be designed and laid in accordance with relevant IS Specifications.

   The automatic sprinkler system discovers fire, sounds alarm and extinguishes the smallest fire. In sprinkled building, water damage will be less because the amount of water necessary for extinguishing is smaller, hence all mill buildings must be 'sprinkled'. Such installations are expensive but their worth is justified. High pressure automatic sprinklers of special design must be provided in generating stations, transformer houses and oil godowns. They should be used after power is switched off. A trained fire fighting squad shall be maintained round the clock within the mill premises.

7. **General Safety Precautions :**

   Mill compounds must be regularly cleaned and housekeeping both inside as well as in the yard should be of good order. Overhead structures in all departments must be regularly cleaned and floors swept during each shift. Electrical equipment shall be satisfactorily maintained and periodic check-up is necessary. Risk. of overheating can be reduced by providing efficient lubrication and day-to-day maintenance of all machines, bearings and moving parts. Adequate guarding for machines should be provided particularly on blowing and carding machines. Smoking should be prohibited within 6 mt of process and storage blocks and it is advisable to provide smoking booths.

10 HEALTH HAZARDS AND CONTROLS

Some important health hazards in a textile industry are as follows :

Accidents to fingers, hands and other body parts are due to a variety of textile machinery and their hundreds of moving parts. Constant machine guarding is the best solution. Noise and vibration are incidental hazards. **Byssionosis** is a lung disease due to prolonged exposure to high concentration of cotton dust. Extraction and suppression is the best remedy. Sch. 27, Rule 102, GFR requires this. See Part 3.2.

Increased humidity and temperature cause discomfort to workers. Limits of dry and wet bulb temperatures should be maintained. Well designed and maintained AC plants are more comfortable.

10.1 Health Hazards in Cotton Textile Industry :

1. **Cotton Dust and Byssionosis :** According one survey 20% (approx. 3 lakh) of the textile workers in mills were found victim of byssionosis. It was 14% in carding section and 10% in spinning and winding sections.

   Measurement of cotton dust concentration in 8 units in India showed it from 3.4 to 5.6 mg/m" in blow room and 0.1 to 2.2 mg/m^3 in card room. Another survey showed cotton dust level as under:

At Kanpur - 7.85 mg/m^3
At Delhi - 5.50 mg/m^3
At Ahmedabad - 4.00 mg/m^3
At Mumbai - 3.90 mg/m^3

The threshold limit suggested is 0.2 to 0.75 mg/m^3 2nd Schedule of the Factories Act prescribes 0.2 mg/m^3 lint free raw cotton dust. ILO prescribed cotton dust values are as under: TWA OSHA -

- 0.2 mg/m^3 in yarn manufacturing.
- 0.5 mg/m^3 in other operations.
- 0.75 mg/m^3 in slashing and weaving.

STEL ACGIH - 0.6 mg/m^3 .
IDLH - 0.5 mg/m^3

Vacuum stripping and suction exhaust arrangement attached to carding machines, lint and dust collectors and general exhaust ventilation are necessary to minimise the flying cotton dust. Proper dust mask or cotton cloth should be given to workers.

Byssionosis is an occupational disease caused to many mill workers by the cotton -dust. This name was given by Proust in 1877. It is a lung disease like TB or Asthma and reduces working capacity of a worker. After working for 5 to 10 years in cotton dust area, respiratory problem starts. Initial symptoms are cough or bronchitis, chest pain, breathlessness, emphysema and phlegm. Ultimately the lungs are damaged. The victim gets exhausted soon by a small work. He feels energy loss and becomes unfit to work. Its major hazard area is spinning department, though it can happen to winders and weavers and also to flax, hemp or jute workers. Under section 89 and the Third Schedule of the Factories Act, byssionosis is a notifiable occupational disease and the medical practitioner noticing this disease has to report to the Inspector of Factories, otherwise he is liable for penalty.

For its diagnosis (1) Occupational history of the worker and (2) Lung function test are required. The effected worker is examined on tKo-first day after his holiday and also at the"~nd of his shift after working. His loss of working capacity is measured. Workman Compensation is available under WC Act or ESI Act.

Factory Medical Officer should check such workers periodically. His workplace must be changed soon after the first detection. X-ray and gradation reports should be maintained. There is no medical remedy for this disease. Therefore its prevention is the only best solution. Local exhaust ventilation attached with machine, room exhaust ventilation, water sprinklers and use of cotton dust mask or respirator are the effective remedial measures.

Workers engaged in cleaning of cotton dust or in its high concentration must be provided with air line respirator and hood or efficient face mask. Instead of broom-stick cleaning, vacuum cleaning machine should be used to minimise the flying particles.

2. **Heat and Humidity:** Higher temperature due to closed operations and work rooms, humidity (to reduce thread breakage), heat generating processes such as sizing, kiers, drying range, stenter, hotdyeing, singeing, polymerising or curing, steam and oil heaters, hot air dryers, boilers etc., create higher temperature in spinning and processing departments which if exceeds 29.5°C (85°F) (threshold or effective temperature), or humidity is increased, causes discomfort and fall in productivity. Therefore the room temperature" must be, controlled @ 25.5 to 29.5°C (78 to 85°F)

by good natural and mechanical ventilation (See Chapter 10). Workers should be relieved at short interval from high temperature zone. Air conditioning is desirable. Hot metal parts should be insulated.

3. **Noise :** High noise in weaving and ring frame department causes mental stresses and may result in a hearing loss which is an occupational disease under the Factories. Act. Permissible limit of 90 dB for 8 hr. working should not be exceeded.

One survey in a mill'at Bombay indicated the noise levels in Spinning Dept. - 96.5 dB, Doubling machines - 97.6 dB, Winding machines - 98.5 dB, Auto loom shed - 99 dB and Non-auto loom shed - 102 dB. Use of sound absorbing material is effective but expensive. Use of ear muffs or ear plugs (glass wool) is the most practical remedy and the workers must be trained to wear them. In Nigeria, it was observed that due to use of ear protection individual efficiency was increased by 12% and overall production by 1%. The long term solution is the design of noiseless looms.

Legally Sch. 23, rule 102, GFR is applicable.

4. **Weaver's Cough :** This is caused by inhalation of sizing materials, 50% of which comes out during weaving. As the name suggests the workers of loom shed are prone to it. Good ventilation dilutes the effect.

5. **Cancer and Coronary diseases :** These diseases like bladder cancer, chrome eczema or chrome poisoning, dermatitis are caused due to the chemicals like lead chromate, potassium or sodium bichromate, toxic solvents, titanium dioxide, hydrogen sulphide, sulphur dioxide and trioxide. Local exhaust system near toxic fume generation, chemical respirators, gloves, aprons etc. are useful. Non or less hazardous substitutes should be utilised. Medical health check-ups and advice should be followed. Training and supervision will also help.

6. **Machinery hazards :** Foregoing parts 6 to 8 have classified and explained process-wise machine hazards in textile industry. Newer machinery has reduced many of these hazards. The most dangerous parts of textile machines are main motor and gear drives, head stock gearing of spinning frames, revolving beaters of blow-room machines, card cylinder, flying shuttles and loom gears, picking stick and in-running rolls of processing machinery. Specific hazards of jet dyeing and other pressure vessels have also caused many accidents. The fixed guards, interlocked guards, nip guards and other safety devices should not be tempered with or kept open while machinery is in motion:

7. **Material handling :** Heavy rolls and other machine parts and bulk containers are to be handled in textile industry. Excessive weights may cause health injuries, strain and pain. Mechanical aids should be used to lift, carry and handle such heavy loads.

8. **Poor lighting :** Many textile processes require high standards of illumination, such as drawing in threads through healds and reed, weaving and processing of coloured cloth, jacquard (design) weaving, fabric defect checking, folding and packing etc. Poor lighting on such processes causes eye strain. Poor lighting in passage ways, corners, stairs, platforms, confined spaces, tanks, pits and vessels, unguarded machinery and slippery surfaces may cause accidents. Therefore in addition to providing sufficient lighting (see Part 5 of Chapter-9), window glasses, lamps and tubes should be regularly cleaned and local lighting should be provided where required.

9. **Shuttle Kissing :** Suction shuttles of ordinary (non-auto) looms need thread (weft) sucking by mouth through shuttle eye (small hole) and pirn bobbin many times during a day. Dirt, dust or

broken fibre ends are drawn into the throat. The same shuttle may be used by different workers in different shifts. Therefore this is unhygenic and infectious method. Non-suction shuttle or pirn bobbin battery requiring no kissing by mouth is the only remedy.

10. **Overtime work :** Legal limit of 8 hours a shift is hardly followed in thousands of small and medium scale textile industries. 12 hours a shift has become a routine working. This certainly causes health hazards. This causes more harm to women and child workers. More working hours cause physical, mental and nervous strain and result in more accidents and sickness rates. Full co-operation of employers and employees can solve this problem.

11. **Welfare provisions :** Large scale factories have lunch room, rest room, canteen, ambulance room, creche, washing facilities, free medical examinations, transport facilities etc. But majority of small and medium scale factories do not have such facilities. This affects the health and general well being of the workers.

12. **Fire and Explosion hazards :** Cotton is easily combustible material. Solvents used in processing department can cause fire and explosion both. For details see part just following.

10.2 Health Hazards in other Textile Industry :

1. **Manmade fibres (mmf) :** Fire and explosion is the main risk from solvents and nitrocellulosic materials. All flammable materials should be stored in specially designed separate' building and its flow should be through closed system. All sources of ignition including static charge should be eliminated. Electric fitting should be flameproof.

Toxic effects due to H_2S, CS_2, C_6H_6, acetic acid etc. should be reduced by local exhaust ventilation. Workers should be given respirators.

Spillage of water and other solutions may cause slipping hazards. Protective clothing is necessary for wet processes. Machine guarding to machineries is similar to cotton industry.

Glass wool manufacturing induces infrared emissions from molten glass. Heat absorbing screen is required. Flying or breaking glass particles may cause skin penetration. Resins, hardeners and accelerators may cause skin irritation. Protective clothing, good hygienic practices and medical advice are necessary. Dust fumes need local exhaust ventilation.

Synthetic fibres are made from chemicals or petrochemicals. Nylon, polyester, polyolefins, polypropylene, polyurethane etc. are well known. Machine guarding is required as in case of other textile machines. The large quantities of solvent vapours given off during spinning and extrusion pose fire, explosion and poisoning hazard and need local exhaust with safe discharge and respiratory protection. Delivery of toxic and flammable substances through pumps and pipes reduces hazards of manual handling and direct exposure. TLV, LEL and other safe limits must be maintained. Sparks should be eliminated. Electric equipment should be flameproof. Effective earthing to machines and vessels shall prevent dangerous spark. Static charge eliminators to machines are necessary. Workers should wear footwear with rubber soles.

2. **Flax & Linen industry :** The fibres of flax plants are used to make linen cloth, towels, nets and ropes. The fibre is light, strong and absorbent Its strength increases on wetting.

Machine guarding on rollers, pulley-drive; and other moving parts is essential. Flax dust may cause Mill fever and Weaver's cough chronic bronchitis and byssionosis. An ILO report (1965) gives following figures for flax dust levels and byssionosis prevalance :

Process	Mean total dust concentration mg/m3	Byssionosis prevalence (% all grades)
Pre-preparers	6.7	44.0
Prepares	2.7	30.0
Wet-finishers	0.6	3.6
Other finishers	1.4	0.7

Dust measurement at 6 months interval by a trained industrial hygienist is useful. Fine dust is removed by passing air through canvas filter. Coarse dust is extracted by a cyclone extractor. Hackling machines and carding engines need hood enclosure and exhaust system at the sources of generation.

For noise reduction, sound absorption treatment to walls, ceiling and floors and isolating mounts to machines are necessary. Process segregation by separate rooms of heavy partition walls and ear muffs to workers reduce noise problem.

3. **Jute industry :** See Part 5.2
4. **Silk industry :** Silkworms were reared in homes where CO poisoning was noticed in Japan. In reeling raw silk, dermatitis was noticed. Handling raw silk may produce skin and respiratory allergy.

   Very good lighting is required in the weaving of coloured silk yarn. Temperature, ventilation and humidity control are important at all stages. Reeling bath temperature should be lowered to control skin effect Exhaust ventilation on bath and frequent replacement of water are necessary. Machine guarding is required as in case of textile industry. See also Part 33 of Chapter-23.

5. **Wool industry :** Like cotton textile machines/wool textile machinery also needs effective machine guarding and spacing. Anthrax is possible to wool sorters. Chemicals used may cause poisoning, eye burning, gassing etc. Selection of less harmful chemicals, local exhaust ventilation, good washing facility, PPE and strict personal hygiene are necessary. Dust, temperature and noise control are also necessary.

11 EFFLUENT TREATMENT AND WASTE DISPOSAL IN TEXTILE INDUSTRY

Textile effluents are generally coloured and contain soluble (organic and inorganic) and insoluble (suspended) impurities and possess high BOD and COD. Therefore their treatment and safe disposal are necessary and statutory.

Effects of textile effluents :

(1) On Water courses :

S. No.	Impurity	Content	Effect
1	Colour	Dyes	Colourification, Photosynthesis is affected.
2	Suspended impurities	Collodial & suspended particles	Turbidity of receiving water.
3	pH	Alkalis	Alkalinity disturbs aquatic life.

4	Oils & Grease	Mineral oils	Form blanket and prevent O_2 entry in water.
5	Dissolved minerals	Inorganic sodium salts	Increase salinity of water.
6	Toxic chemicals	Chromium, sulphide, chlorine and aniline dyes	Toxic effect to fish and microbial organisms.
7	Oxygen depletion	Starch, dextrin, sulphide, nitrite etc.	Demand O_2 from water and affects aquatic life.

(2) On Land:

The excess content of sodium and boron of textile wastes adversely affects crops. High sodium alkalinity combined with salinity impairs the growth of plants. Suspended solids and sodium prevent root penetration in land and soil texture is spoiled.

(3) On Air:

Continuous addition of CO_2 and other particles due to fuel (coal, LDO, gas) burning in boilers and stenters, and toxic fumes of chlorine, acids, H,O, and flammable vapours from volatile solvents pollute the air and surrounding environment.

Effluent generation flowchart is as under -

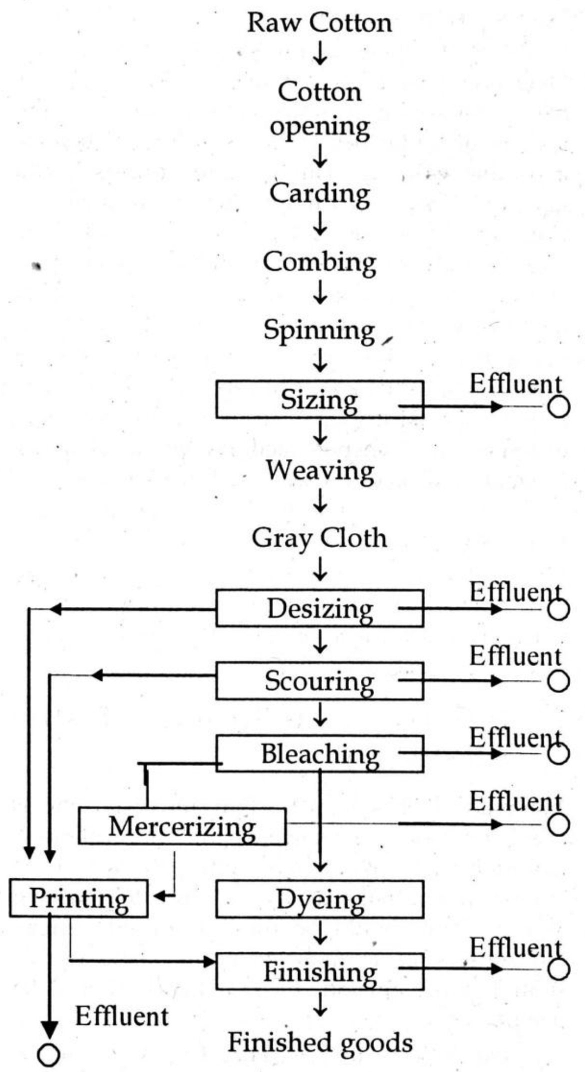


Fig 21.10 : Effluent Flowchart

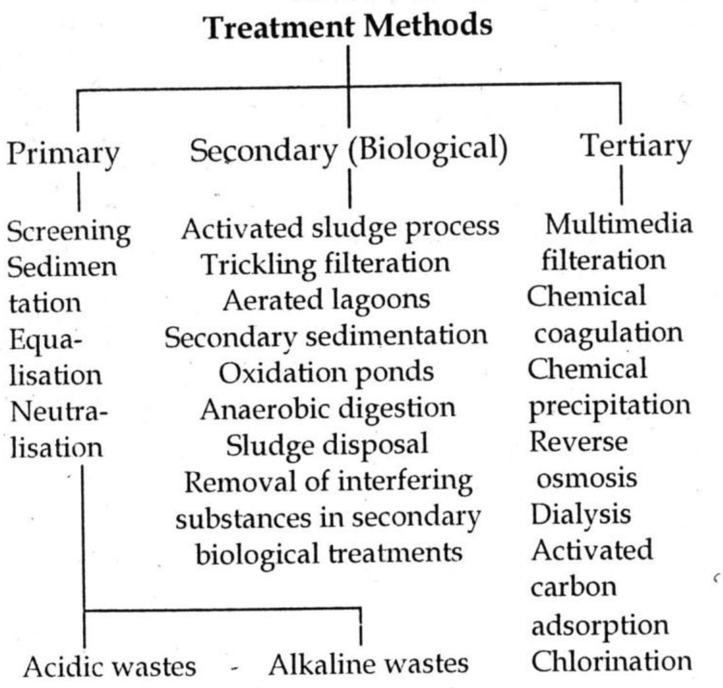
Reduction of Pollution Load :

To reduce costs and complexity of treatment, it is first necessary to reduce pollution load of the effluents. It also results in saving of costly materials. Good housekeeping, controlled and efficient use of dyes and chemicals and closer process controls are essential for this purpose. Some important methods are as under :

1. Waste segregation.
2. Recovery and reuse.
3. Substitution of low pollution load substances.
4. Judicious use of chemicals.
5. Process changes.
6. Economical water use.

Treatment Methods:

Three stage treatment methods of textile effluents is as tabulated below :



Other inetilodsure

1. Colour removal.
2. Recovery and reuse of waste water.
3. Conservation- and reuse of water.

For details of these methods, books on pollution control methods should be referred. Please see reference No.7 at the end of this chapter.

Diagram of effluent treatment plant in textile processing industry is given in Fig. 21.11

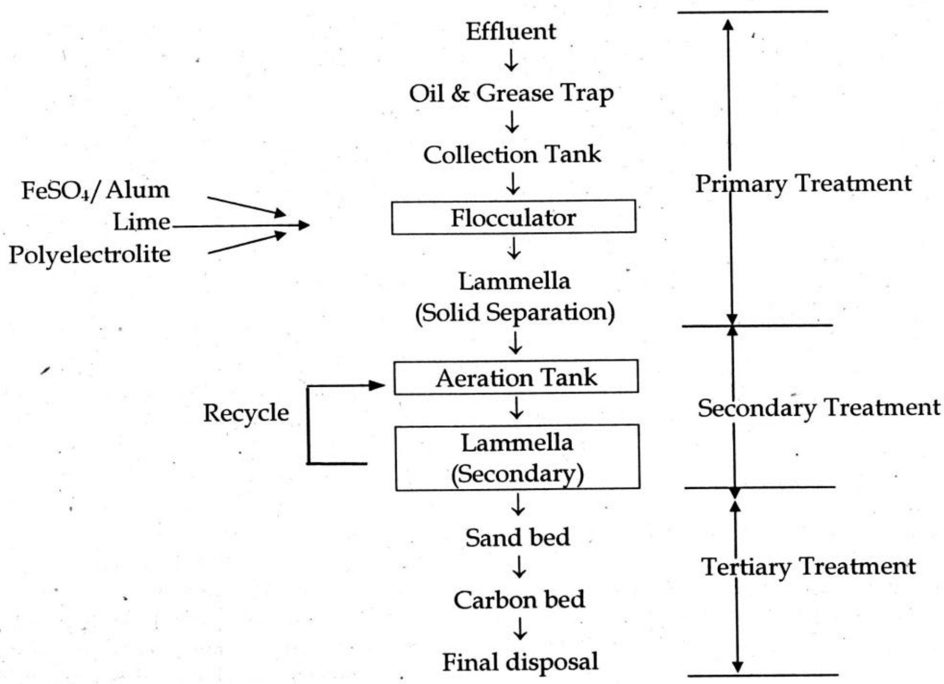


Fig 21.11 : Effluent Treatment diagram for textile processing industry

Tolerance Limits:

IS 2490 (Part I to 10) and Schedule I & VI u/ r 3 & 3A of the Environment (Protection) Rules, 1986 prescribe tolerance limits applicable to textile effluents.

Characteristics of raw (untreated) effluent and required parameters of process houses are shown ii the table.

Process House Effluent Characteristics

No.	Parameter	Before Treatment	Required after Treatment
1	pH	6.6-8.0	6.5-8.5
2	Color	1000-1500 unit	100 unit
3	Suspended Solids	600-900 ppm	100 ppm
4	Total Dissolved Solid	10000-14000 ppm	2100 ppm
5	Oil & Grease	20-25 ppm	10 ppm
6	BOD	500-600 ppm	30 ppm
7	COD	1600-2200 ppm	100 ppm
8	Ammonical Nitrogen	0-5 ppm	50 ppm

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. Need of safety in textile industry.
2. Statutory provisions for safety of textile machinery.
3. Flow chart of a composite textile processes.
4. Flow chart of spinning and weaving OR Finishing processes.
5. Flow chart of long staple finishing processes.
6. Flow chart of synthetic fibre manufacture.
7. Flow chart of Filament yarn (Nylon - 6)
8. Flow chart of Oriented yarn (LOY, POY etc.)
9. Manufacturing process of spun (oriented) Yarn (POY, FOY etc.)
10. The merits and demerits of rotor spinning.
11. Hazards and safety measures of Blow room machinery.
12. Hazards and safety measures of Carding machines.
13. Hazards and safety measures of Sliver and Ribbon lap machines.
14. Hazards and safety measures of Combers and Draw frames.
15. Hazards and safety measures of Speed frames.
16. Hazards and safety measures of Ring frames.
17. Hazards and safety measures of Doubling machines (frame).
18. Hazards and safety measures of Winding machines.
19. Hazards and safety measures of Warping machines.
20. Hazards and safety measures of Sizing machines.
21. Hazards and safety measures of power looms.
22. Hazards and safety measures of Bleaching process.
23. Hazards and safety measures of Washing machines.
24. Hazards and safety measures of Jigger machines.

25. Hazards and safely measures of Calendar machines.
26. Hazards and safety measures of Jet dyeing machines.
27. Hazards and safety measures of Stenter machine.
28. Hazards and safety measures of Drum washer machine.
29. Hazards and safety measures of Printing machine.
30. Hazards and safety Carbonising machine.
31. Health hazards and controls in Cotton .textile mill.
32. Health hazards and controls in Silk and Wool industry.
33. Fire and Explosion hazards in Textile industry.
34. Effluent treatment flow chart of a textile mill. Explain by a diagram.
35. Types of effluent treatment methods in a tovUlp mill

2. Write short notes on :

1. Inference of accident case studies in a textile mill.
2. Types of fibres and their use.
3. Spinning preparatory OR Weaving preparatory process.
4. Spinning processes OR Finishing processes.
5. Jute Manufacture.
6. Rotor Spinning.
7. General Safety measures of textile processing (finishing) machines OR Safety devices on a Singeing machine.
8. Hazards and controls of flying shuttles.
9. Picking stick assembly.
10. Hazards and safety aspects of a Washing tank.
11. Kiers and Agers.
12. Byssionosis OR Weaver's Cough.
13. Heat and Humidity problems in a textile mill.
14. Fire hazards in cotton go-downs.
15. Methods to reduce pollution load in a textile mill.

3. Explain the Difference between

1. Cotton and Man- made Fibres
2. Thermic fluid heater and Drier.
3. Ginning and Pressing.
4. Ring frame and Doubling frame.
5. Pirn winding machine and a Warping machine.
6. Bleaching and Dyeing.
7. Spinning and Weaving.
8. Fibre and Fabric.
9. Short staple fibre and Long staple fibre.
10. Gilling and Carding.
11. Ring spinning and Rotor Spinning.
12. Singeing machine and Curing machine.
13. Stitching machine and Folding machine.
14. Fire hazards and Explosion hazards in a cotton textile mill.
15. Primary and Secondary effluent treatment methods.

4. Comment on the following explaining whether it is true or false ?

1. Women or children can be employed toward delivery - end side of a cotton opener.
2. Section 30 (F.A) is not .applicable to hydro extractor.

3. Rule 61 (GFR) is applicable to drum washers.
4. Copper sizing cylinder is a thin wall pressure vessel.
5. PET fibres pose no health hazards.
6. PET fibres pose environmental hazards.
7. Beaters are most dangerous parts in below room machinery.
8. Rotor spinning machine cannot spin combed yarn.
9. Bleaching and dyeing of jute is not possible.
10. Trip cum distance guard is required on a Warping machine.
11. Rule 61 (8) for thin wall pressure vessels is applicable to sizing cylinders.
12. Vertical picking stick is less dangerous than horizontal picking stick of a loom.
13. Hydro-extractor does not need interlocked top lid.
14. Jigger machine needs splash guards.
15. Calendar machine needs safety valve.
16. Stenter machine needs exhaust fans.
17. Jet dyeing machine needs de-pressure device.
18. Drum washer needs PRV and safety valve.
19. Sanforizing .needs steam line safety.
20. Towel cutting machine needs guard on delivery end of towel.
21. High noise area in a textile mill is its cloth department.
22. Jacquard (design) weaving requires better lighting condition.
23. Mmf manufacture has toxic hazards.
24. In silk industry dermatitis is not possible.
25. Glass wool processing has dust hazard but no infrared radiation hazard.
26. Flax dust cannot cause Byssionosis.
27. Employment of Industrial hygienist is justified in a textile mill.
28. Explosion is possible in a polymerising machine.
29. Cotton mixing room does not pose fire hazards.
30. Solenoid valve is essential on fuel supply line of a singeing machine.
31. Flameproof electric fitting is required in a fuel fired singeing machine room.
32. Electric heaters should be interlocked with exhaust fan drive and cloth drive of a curing machine.

5. Explain the following terms from safety point of view

1. Fibres from Animal origin.
2. Card OR Comber.
3. Kier.
4. In-running nip.
5. Head stock gearing.
6. Drying range.
7. Artificial humidification.
8. Byssionosis.
9. Cotton opener.
10. Polymerising machine.
11. Yarn singeing machine.
12. Sanforizing.
13. Texturising.
14. Bobbin shield.
15. Knee brake.
16. Duck bill and Hitter.
17. Weaver's cough Shuttle kissing.
18. Tolerance limits of effluent.
19. Padding mangle.

20. Scouring process
21. Hinged swing door.
22. Micro switch.
23. Lap rod.
24. Beam flange.
25. Drafting zone.
26. Etching of copper roller.
27. Dust chamber.
28. Flutted roller.
29. Licker in.

6. **Match the words in column 'A.' with appropriate words from column 'B' from safety point of view -**

A	B
Fibres from – Vegetable origin Natural polymer Petrochemical origin Polyvinyl derivatives	 Acrylic fibres Synthetic fibres Viscose rayon Cotton Wool Asbestos
Carding machine Roving frame Ring frame Pirn winding machine Warping machine Draw frame Loom Jigger machine	Dyeing of cloth Gray cloth Weft for shuttle Drawn warp Combed yarn Cone of yarn Sliver Twisted yarn Rove yarn Warper's beam
Cotton opener Carding machine Silver lap m/c Comber m./c Slubber frame Inter frame Ring frame Rotor spinning	Cylinder doors Beater Coiler and draw box Gears Nip guard Rotating flyers Bever whell guard Knot-free yarn Knee brakes Ring travelers
Warping machine Sizing machine Loom Bleaching machine	Nip guards Photo electric device Fume exhaust Shuttle guard Doffer wheel
Washing Tank Hydro extractor Calendar machine Jigger machine	Chemical goggles Heavy rolls Railing on hot water tank Brake

Drying Range Ager machine Stenter machine Jet dyeing machine Drum washer Stitching machine Shearing machine Carbonising unit Folding machine	Use of chain pulley block Chain drive guard Rupture disc Exhaust hood and chimney Crank-wheel guard Locking device Acid proof flooring Metal detector ELCB Repeat setting device
Cotton dust Noise Weaver's cough Humidity Bleaching process Shuttle kissing 12 hours shift Anthrax Yarn singeing machine Storage of cotton bales	To reduce thread breakage Sizing material H2O2 Byssionosis Explosion hazard Loom shed Pirn bobbin battery Fire hydrant Wool industry LPG Safety Illegal

7. Give probable causes and controls of the following -

1. Accidents in blow room OR Loom shed
2. Accidents in Sizing OR Carding m/c.
3. Accidents in Dyeing OR Bleaching m/c
4. Accidents in Printing m/c. .
5. Bursting of drying cylinder.
6. Broken shields of bobbins.
7. Processing chemicals.
8. Stentering machines.
9. Ring spinning OR Winding m/c.
10. Carbonising of polyester.

Reference and Recommended Reading

1. The Factories Act and Rules.
2. BIS Handbook.
3. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
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5. Synopsis of the Gujarat Factories (Amendment) Rules, 1995, by K.U. Mistry, Siddarth Prakashan, Ahmedabad.
6. Rotor Spinning - by Dr. Eric Dyson, The Textile Trade Press, Stockport, England.
7. Treatment of Textile Processing Effluents by N Manivasakarn, Sakthi Publications, Coimbatore-21.
8. An Introduction to Spinning by Morton & Wray.
9. Repair and Adjustment of Textile Machines by T granousky.
10. Gujarati Booklet : Byssionosis Control, UnnaH Vikas Shikshan Sansthan, Gl/200, Azad Society, Ahmedabad - 380014, or PRIA, New Delhi – 110062.

CHAPTER – 22

Safety in Construction Industry

THEME

1 SCOPE OF SAFETY IN CONSTRUCTION WORK

1.1 Basic Philosophy : 03235213618

Construction activity is not only an oldest industry but also the largest one in many parts of the world. It started with the basic human need 'shelter, home or dwelling house' and is ever expanding with the growing population and their growing needs of residential and commercial buildings, shops, offices, factories, roads, bridges, dams, railways, power transmission lines, communication lines, towers, columns, chimneys, silos, oil and gas installations, air fields, hoists, lifts, many types of underground, under-water and aboveground works and works of excavation, foundation, construction, alteration, renovation, repair, maintenance, demolition, dismantling, erection, fabrication etc.

After agriculture, construction seems to be the second largest economic activity. If mining and quarrying are considered as a part of or inclusive of construction industry, it becomes the largest of all industrial activities. Some figures of the most advanced country, USA, are as under :

Table : 22.1 Deaths & Death Rates, USA :

	1992	1993	1994	1995	1996
DEATHS					
Agriculture	779	842	814	723	710
Mining, Quarrying	175	169	177	156	150
Construction	889	895	1000	1043	1000
Manufacturing	707	698	734	638	610
Trans. & Pub. Util.	767	753	819	822	750
Trade	415	450	492	451	460
Services	601	631	676	655	610
Govt.	586	528	534	523	510
DEATH RATES (per 1 lakh workers)					
Agriculture	24	27	24	21	21
Mining, Quarrying	25	28	30	26	25
Construction	15	15	16	16	15
Manufacturing	4	4	4	4	3
Trans. & Pub. Util.	13	13	13	13	12
Trade	2	2	2	2	2
Services	2	2	2	2	1
Govt.	3	3	3	3	3

Source : Accident Facts, 1997, NSC, USA.

In our country reportability of construction accidents is not known. But following figures are reproduced below from Indian Labour Statistics, 1991-93.

NIC Code 50 & 51 represents construction and construction activities and all India fatal accidents in this industry are as under :

Year	Fatal Accidents
1986	114
1987	141
1988	100

These figures are not reported for many years and from many States and many works. Therefore this data is incomplete and misleading.

Table 22.1 makes it clear that the combined deaths and death rates of construction and mining industries are more than even agriculture. Decrease during last years indicates that safety activities can certainly decrease the accidents. This proves the scope and importance of safety in construction industry.

As per rough estimate about 2 lakh firms and more than 200 lakhs workers work in construction industry in India. Thus mostly it is labour oriented and unorganised. Workers are mobile, mostly illiterate and work on contract basis. They work under sun and rain, cold and wind and dust and sand. Their working conditions are mostly unsafe, hazardous and unhygienic. Their workload is heavy and demands heavy muscular work. Their work and workplaces are not of permanent nature and therefore not governed by any law like the Factories Act. The Building and other Construction Workers Act 1996 and the Rules 1998 have been passed and implemented in 2006. The overall working conditions of majority of construction workers are, therefore miserable.

Basic philosophy to improve their working conditions is the safety philosophy. It should be realised that construction is inherently hazardous industry, , contract based industry, demands heavy work load, contributes high frequency and severity of accidents, less protected by law, movable and needs continuous efforts to maintain safety at all levels. It may not be possible to completely eliminate the hazards, but it is certainly possible to minimise them by enforcing certain safety precautions. The working and service conditions of the workers need to be improved. Peculiarity of accidents is well known. Falling from height, struck by falling body including landslide, material and equipment, striking against object, falling on the flat or into pit, sump, gutter etc., occupational diseases of lung, skin, locomotors and nervous system, electrical and pneumatic tools, unguarded machinery, heavy vehicles and working without safety equipment are the major causes of accidents. Mechanization can eliminate some manual work hazards. Work permit system, prompt supervision and first-aid, use of personal protective equipment and proper tools, training and education and project safety committee are some of the remedial measures.

Safety philosophy for construction work should be based on the following points:

1. Safety policy statement and strict adherence to it.
2. Safety cannot be delegated. It is a line function.
3. Safety is everybody's responsibility.
4. It is an integral part of all project activities.
5. Good planning and advice, and discussion with contractor and subcontractors are essential at design or initial stage.
6. Safety ensures success with satisfaction.
7. Work permit system is desired for all hazardous works.
8. All construction accidents should be recorded, reported and investigated for the purpose of safety and costing.
9. Standards, Codes and Statutory provisions must be followed. Safety manuals should be prepared for contractors, workers and supervisors, and
10. Education, training and supervision for safe work methods and use of safe tools and equipment play an important role. See Part I of Chapter-? also.

12. Parameters of Safety in Construction:

Peculiarities and parameters .governing safety in construction industry are, now, discussed in the following paragraphs.

1.2.1 Studies, Statistics and Results :

Statistics and studies on construction accidents are not much available as factory accidents. This is mainly because of no exclusive authority, late and poor administration, non report ability and no complete compilation of such data.

In one study which lasted for 15 years, Levitt (1987) highlighted the hidden costs of construction accidents. He concluded that these accident costs mostly exceeded the gross-profit of most of the firms in construction industry. He also found that all managers who had good safety records do three things:

1. Motivate their subordinates to attend to safety.
2. Provide training for managers and workers at all levels, and
3. Insist that work is carefully planned.

Champoux et. Al. (1987) studied 357 accidents in construction industry and identified the higher risk areas of work and orgnaisation as targets for prevention. High risk tasks are crucial to ergonomist and all those working for safety in construction.

National Institute of Training for Industrial Engineering (NITIE), Bombay conducted a study (1989) and after interviewing site engineers, safety officers and labourers on site, it was concluded that the reasons for health and safety problems were -

1. The absence of safety rules and regulations.
2. The unorganised nature of work.
3. Almost total lack of any need for safety felt by engineers and contractors and
4. Absence of trade unions for welfare and health.

The main safety measures suggested were
1. Compulsory use of safety helmets.
2. Use of safety belts for working at heights greater than 1.5 m.
3. Provision of canvas around the scaffolding to prevent falling objects from striking people.
4. Good and tidy housekeeping.
5. Provision of proper tools and
6. Adequate training to new workers.

Occupational health diseases were studied by Englund, Triebig, Duivenbooden and Husmark (1987). Diseases of the skin, locomotor, circulatory, respiratory and nervous system were noticed amongst construction workers. A few occupations handling asbestos, showed respiratory cancer in plumbers and insulators.

Fatal occupational injuries in Construction, by type of event or' exposure, in USA, 1995 are reported as under (Accident Facts, 1997) :

Out of total 6210 fatal accidents in all occupations in 1995, 1043 i.e. 16.79% fatal accidents took place in construction and comparatively it is the highest in this industry. Its causewise breakup is as under:

Fall to lower level	324
Electric current .	163
Traffic accidents	117
Struck by object	104
Struck by vehicle, mobile equip.	079
Caught in or crushed in collapsing materials	052
Caught in or compressed by equipment or object	033
Others	171
Total	1043

One study of construction accidents in our country gives following figures.

Type of Accident	Temporary Total	Permanent Partial	Permanent Total

	Disablement %	Disablement %	Disablement %
Handling of Materials	24.3	20.9	5.6
Falls	18.1	16.2	15.9
Falling object	10.4	8.4	18.1
Machines	11.9	25.0	9.1
Vehicles	8.5	8.4	23.0
Hand Tools	8.1	7.8	1.1
Electricity	3.5	2.5	13.4
Others	15.2	10.8	13.8
Total	**100**	**100**	**100**

Following figures were 'published in Industrial Safety Chronicle, Oct-Dec, 1996, as ILO data for Construction Sector :

Country	Accident Rate per 1000 workers	Fatality Rate per 1000 workers
Austria	142	25
France	125	30
Germany	120	16
Mauritius	70	15
Mexico	70	24
Spain	138	38
Sweden	48	9
United States	70	25

To compare with this. Accident Rates for the year 1992 and 1993, given by Construction Wing of NPC (Nuclear Power Corporation, India) are reported as 10.05 and 12.06 respectively. This indicates that our construction accidents are 5 to 14 times less than those of foreign (developed) countries.

Similarly Fatality Rates for 1992 and 1993, given by the same NPC, India are 0.124 and 0.120 respectively and again these figures when compared with ILO figures, indicate that fatal construction accidents in our country are 75 to 320 times less-than those in western countries.

The reasons of this anomaly, as stated in the article are as under :

1. Gross under-reporting of accidents by Indian industry.
2. ILO figures include first aid injuries while ours are reportable (48 hours absence) accidents.
3. ILO figures are old when safety efforts in western countries were poor.

Now some figures of recent construction accidents in our country are given below.
37.5 °/ 32.5 ~ 12.5 °/ 07.5 °/ 10.0 °/ inn °/

Some 30000 workers were employed at one place in Gujarat constructing various plants during 1991 to 1997. The large civil construction and structural steelworks including fabrication and erection o buildings were carried out through competent contractors and sub-contractors. Safety Officers and safety supervisors were also employed exclusively for contract workers. Record of all accidents, reportable o not reportable, was maintained, studied and used in further prevention of accidents. Its summary is a under:

From March 1994 to July 1997, total fatalities were 39. Its cause-wise percentage break-up is as under :

1.	Struck by falling objects, structures, plant, mobile construction equipment etc.	37.5%
2.	Fall	32.5%
3.	Electrical	12.5%
4.	Traffic accidents	07.5%
5.	Others	10.0%
	Total	100%

Comparing above figures with the same causation figures of USA, UK, Germany, Sweden, Japan and Canada (from Safety &: Health Journal of USA - 1994), it is deduced that, all over the world, t1ie first two major causes of fatal accidents in construction activity are :

(1) Fall from height and
(2) Struck by falling objects.

Therefore safety work to eliminate these causes need first priority.

Statistics of nonfatal accidents of above mentioned construction during 1995 to 1997, gives following figures :

1. Types of Accidents - Fall from heights 15 to 22%, struck by falling objects 13 to 33%, struck by others 21 to 38%, Electric shock 2 to 7%.
2. Agency/ Activity - Material handling 27 to 41%, Work at height 14 to 21%, Hand/Power tools 10 to 12%, Fabrication & election 12 to 13%.
3. Body parts injured - Hand, Fingers & arms - 22 to 35%, Head & scalp - 16 to 18%, Foot &toe 12 to 15%, Leg & thigh 9 to 17%.

As a summary from various such records, general classification of hazards at construction can be drawn as under :

Hazards at Construction :

1. Fall of Persons - Fall from height, fall through opening, collapse of scaffold, structure failure, tripping.

   Fall from height may be due to non-use or failure of safety belt, lack of proper access, nonuse of proper ladder etc.

   Fall through opening may be due to unguarded opening or poor guarding.

   Collapse of scaffold may be due to its improper design, no toe board, no means of access. Minimum dimensions are : Board width 6", thickness I" and guard rail height 30 to 36".

   Tripping may be due to loose object/cables etc.
2. Fire : Due to welding, gas cutting, smoking, gas cylinders, scattered wooden material/ rubbish, paints/thinners, temporary shed etc.
3. Electrocution : Electric shock, burns, damaged cable, no earthing, no ELCB, no use of 3 pin plug/socket, work by non-qualified electrician etc. .
4. Material Handling : No training,- excessive weight lifting, improper or failure of lifting tackles, slings etc.
5. Transport Accidents : Untrained driver, not obeying traffic rules, reversing without signalling, over-speed, speed-breakers, poor brakes, poor lighting etc.

6. PPE : Not using helmet, safety shoes, hand gloves, safety belt, respirators etc.
7. Others : Noise, vibration, dust, gas, fumes, cave in, night work, overtime, intoxication etc.

This suggests the direction of accident prevention work in construction activity.

1.2.2 Site Planning and Layout :

In construction activities, scope of site selection is less though not zero. Mines are at fixed places and cannot be shifted. Builders or organisers generally purchase the site where land is available at low price and where .contractors and workers have to work. In a fixed factory premises, construction is to be carried out in a limited space. In dense population, construction of high rise (multi-storeyed) building needs working at height. Gutters and underground piping have fixed tracks available. Underwater work has fixed destinations and long pipelines are passed through the shortest possible distance for economic reasons. Therefore in a limited scope of site selection, planning and layout becomes most essential on .the available site.

Refer part 6 and 7 of Chapter 7 for planning, design and layout.

First, plan for the whole and then for the detail. Plan site layout, plot layout and equipment layout as per requirement. Alternate layouts should be prepared for selecting the best one. Process flow diagram and stages or sequence of work should be decided. Each work should be subdivided in steps accounting for safety precautions and responsibilities. Facilities for water, fire fighting, first-aid, tools and equipment availability, roads, vehicle movement, parking, smoking booths, sanitary blocks, creche, canteen, control room, safe entry, exit and escape route etc. should be properly planned. Topography, geology, weather, environment, separation distances, service corridors, overhead work (pipe bridges, tanks, slabs etc.), segregation etc. should also be considered. Special precautions should be encountered for working at heights or depths (See Chapter 16).

Planning, layout and designing of steel structure, tall towers, metal tanks, vessels, reactors, utilities, piping etc. need Hazop, hazard identification, risk and reliability assessment, strength and stability criteria, inventory reduction, process safety, fail-safe design, emergency shut-down procedure and emergency planning.

Appointment of safety and health personnel, trained supervisors and requirement of adequate first-aid and fire fighting facilities and personal protective equipment should be considered at the stage of planning and budgeting for safety at work.

1.2.3 Safe Access :

For the safety of workplaces and avoiding risk of injury to workers, safe means of access to and egress from all workplaces should be provided, maintained and indicated where necessary.

Section 32 of the Factories Act requires that all floors, steps, stairs, passages and gangways' shall be of sound construction and properly maintained and shall be kept free from obstructions and substances likely to cause persons to slip and where it is necessary to ensure safety, steps, stairs, passages and gangways shall be provided with substantial handrails. Safe means of access are required at all working places. To prevent fall, fencing or other devices are required.

Rule 66A of the Gujarat Factories Rules specifies access for fire fighting and requires unobstructed layout .of plants and building and doors and windows on external walls ->for easy access inside the building.

Means of access may be a ladder-portable or fixed, ramp, runway or stairway. They should conform to the code or standards prescribed.

1.2.4 Safety Work Permit & Checklist :

A format of such permit is given in Table 22.2.

Table 22.2 : Safety work permit (swp), at construction site Date :

Date : SWP No. : ___________

SWP Requested by / Issued to :			Project/ Section	Location of the work to be done	SWP issue Date & Time	SWP Expiry Date & Time
Name of the person	Designation	Company				

Description / Nature of the work	Equipment / tools to be used Tick ✓	Probable Hazards Tick ✓	
	☐ Cranes	☐ Fall of persons from height	☐ Suspended load
	☐ Chain pulley blocks	☐ Falling objects / overhead work	☐ Failure of sling/ tackles
	☐ Slings & other lifting tackles	☐ Fall below ground level	☐ Toxic dust/fumes
	☐ Electrical equipment	☐ Electrical shock	☐ Fire
	☐ Power hand tools	☐ Moving machinery	☐ Poor illumination
	☐ Others (write)	☐ Ionising Radiation	☐ Other causes (Write)
		☐ Eye injury (flying object/arc)	

Following safety measures/ precautions are necessary and have been taken / ensured. Tick ✓	Following safety measures / precautions to be taken / ensured during execution of the job. Tick ✓	Remarks / special instruction if any by issuing authority (pl. specify) viz., display of warning signs to warn against overhead hazards etc.
☐ Proper means of access (Ladders etc.)	☐ All workmen use safety helmet.	
☐ Proper scaffolding / work platform with hand rails.	☐ Workmen use safety belt & anchored properly.	
☐ Static (Rope) line	☐ Use of safety goggles and safety shoes by the workmen.	
☐ Safety net ☐ Safety belt	☐ Provision of shoring / machine	
☐ The crane is in good working condition.	☐ Guards on moving machines are in place.	
☐ The crane operator is	☐ Static lines are provided and	

competent & has licence.	used by the workmen at height.	
☐ Electrical equipment provided with proper earthing.	☐ Cordoning off deep excavation/ hazardous area with warning signs.	
☐ Power supply to hand tools thro' ELCB.	☐ Hand lamps (24V) to be used with safety guards.	
☐ Hazardous area barricaded / protected.	☐ Power supply to lighting through ELCB.	
☐ Condition /capacity of lifting tackles ensured.	☐ Specified work procedure adhered / Tool box talk given.	
☐ Specific work procedures is necessary / available.	☐ Workers possess the required skills.	
☐ Area below hazardous overhead activity cordoned off.	☐ Others (Write)	
Signature of the permittee:	Signature of the site engineer/ Permit issuing authority :	
Signature of the site engineer:	Name & designation	

A checklist for construction safety is given in Table 22.3.

Table 22.3 Construction Safety Checklist

Name and address of the Construction Company __________________ Working at __________________
Audited by __________________________ Audit date ______________

No.	Checkpoints	Comments
1	Helmets used by all	
2	Safety belts used by all during work, if height is more than 2 meters.	
3	Static lines are provided to facilitate hooking of safety belts.	
4	Safety nets are provided where scaffolds not feasible.	
5	Scaffolds are in good condition, ladders are used.	
6	Hand tools are of standard type and maintained properly.	
7	Power tools are in good condition and supply through ELCB.	
8	Grinding machines are with guards.	
9	Welding machine and cables are in good condition.	
10	Gas cylinder of cutting sets are protected from spark.	
11	Hose of cutting sets, pressure regulators and pressure gauges are in good working condition – leak free.	
12	Good insulation, earthing and ELCB are maintained in electrical installations.	
13	Cranes are in good working condition.	
14	Lifting tackles are in good working condition.	
15	Crane is operated by competent operator.	
16	Standard signaling and rigging practices are followed.	
17	Area where heavy erection is done is barricaded.	
18	Area where load is lifted or suspended by crane is	

	barricaded.	
19	Fire hazards are taken care of combustibles removed from site of hot work.	
20.	Fire extinguishers are provided.	
21.	Floor openings are protected / covered / guarded.	
22.	Procedure for critical job is available and followed.	
23.	Persons employed on job possess required skills.	
24.	Vessel entry permits are taken for confined space entry.	
25.	Safety permits are taken to work at height.	

Signature of Auditors ______________________

1.2.5 Good Housekeeping :

See Chapter-8 for details.

Good housekeeping programme should include

1. Speedy removal of scrap, waste, debris, loose and unused materials at regular intervals.
2. Proper storage of materials, tools and equipment. Removal of nails from lumber before stacking.
3. Cleaning of floors, passageways, stairs etc. to remove oil, water, dust etc. Sand, ash, sawdust and proper absorbers can be used.
4. Containers should be provided for collection and separation of waste. Flammable/ hazardous waste should be covered and safely disposed off.
5. After completion of any job, excessive materials, tools and equipment should be lifted and placed in their proper place.
6. Piles of materials should be stable and properly supported.
7. Throwing of material should be avoided. If it is to be thrown, warning signals should be given.
8. Proper painting and colour-coding should be followed.
9. At least at the beginning and end of a shift, supervisors should take round to check above points.

2 STATUTORY PROVISIONS

See Part 7 of Chapter-28 for the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and Central Rules, 1998 under this Act. These rules came into force from 19-11-1998. Out of 252 rules, 200 are pertaining to safety & health of construction workers and prescribe much detail. Henceforth it will be referred as 'BOC Workers Rules 1998' for brevity's sake.

The above rules prescribe for safety committees (for workers 500 or more). Safety Officer (for workers 500 or more), reporting of accidents, medical examination of building workers, occupational health centre, construction medical officer, ambulance room, ambulance van, stretchers, occupational health services, notice of poisoning or occupational diseases, first-aid boxes, emergency care services, provisions for working hours, rest interval, spread over, weekly holidays, notices and registers, latrine and urinal, canteen for workers>250 and payment of wages.

Its Chapter-VI, rules 34 to 54 prescribe for excessive noise, vibration, fire protection, on-site emergency plan (for workers>500), fencing of motors etc., excessive weight, health and safety policy, overhead protection, dust, gases and fumes, eye and head protection, electrical hazards, vehicular traffic, structural stability, stacking of materials, disposal of debris, use of safety helmets and shoes etc.

The other provisions are regarding registration, responsibilities and duties, lifting appliances and gear, runways and ramps, work on or adjacent to water, transport and earth moving equipment, concrete work, demolition, excavation and tunnelling works, steep roof, ladders, catch platform, safety belts and nets, structural frame and frame work, stacking and un-stacking, scaffold, cofferdams and caissons, explosives, piling and powers of Director General and Inspectors.

See Part 2 of Chapter-? for provisions under the Factories Act and Rules. Some provisions regarding construction of a factory, plant layout, lighting, ventilation, safety aspect and preparation of plans stated therein are useful for general construction work also.

3 INDIAN STANDARDS

The Indian Standards on Construction are most useful and must be followed. Some of them are mentioned below :

Safety in excavation 3764, scaffolds and ladders 3696 (Part I & 2), 4014 (Part I & 2), code of practice for design and construction of pile foundations 2911 (Part I to 4), blasting and drilling 4081, underground blasts 6922, demolition of buildings 4130, tunnelling work 4756, piling and deep foundations 5121, structural steel work 7205, concrete framed structures 8989, cement manufacture 12770, construction machinery 7293, handling and storage of building materials 7969, additional construction and alteration to existing buildings 13430, hazards prevention 13416 (Part I falling material hazards. Part 2 fall prevention), working in compressed air 4138, floor and wall openings, railing and toe boards 4912, wooden flush door shutters 2191 (Part I & 2), use of hot bituminous materials 5916, fibre rope slings 9944, dress divers 10291, river valley projects 10366 (Parts I to 10), sewerage system 11972, protective barriers in and around building 13415, reservoirs, guidelines for operation 7323, shallow foundation 1904, masonry walls 1905, loading standards 875, underground air raid shelter 5499, bucket elevators 7167, conveyor belting 6687, conveyor safety 7155, fire resistance test of structures 3809, fire safety of buildings (general), details of construction 1642, fire safety of industrial buildings; cotton textile mills 3079, fire safety of industrial buildings, storage and warehousing 3594, noise reduction in industrial building 3483.

Glossary of terms relating to corrosion of metals 3531, design practice for corrosion prevention of steel structures 9172, cathodic protection of steel structures 8062 (Part I to 4), fire precautions in welding and cutting 3016, approval tests for welding procedures 7307.

See Chapters 7 (Table 7.1 & 7.2), 9, 10, 12, 15, 16, 17, 18, 20, 21, 23, 24, 25 and 26 for the relevant Indian Standards pertaining to construction, building, working at heights and depths, material handling, tools, fire safety, other hazards, PPE and first-aid.

See Parts 6 & 10 of Chapter-23 for other IS. '

OSHA Safety and Health Standards for the Construction Industry (29 CFR Part 1926) may be referred for more interest.

4 CONSTRUCTION MACHINERY

Construction machinery can be classified into three categories as under

1 **Lifting Appliances and Gear :**
Pulleys, chain pulley blocks, winches, hoists, derricks, gin poles, cranes (fixed ad mobile), lifting ropes, slings etc.

2 **Transport, Earth-moving and Material Handling Equipment:**
Power shovels (excavators), bulldozers, scrapers, pavers, road rollers, pile drivers, mobile asphalt layers and finishers.

3 **Plant machinery. Equipment and Handtools**
Concrete mixers and vibrators, pneumatic compressors, pneumatic tools, cartridge operated tools, electric tools, hand tools, conveyors, crusher plants, power generators, engines and silos. ' Some salient safety features of these machines/ equipment are explained below :

4.1 Lifting Appliances and Gear :

For figures and pictures see Chapter 15.

Pulleys : Select the pulleys as per requirement. Steel and nylon rope should not be used together. Grooves should be uniform and smooth and the rope (wire or fibre) should run free. Sheaves, shafts, hooks and pins (with locking) should be checked before use and lubrication shall be provided where necessary. Sheaves should rotate freely on the shaft. The shaft should be free from any defect or crack. Worn out shafts should not be used. Anchorage should be firm and strong. Anti-twister should be used to prevent rubbing of the ropes with one another.

Chain Pulley Blocks : Refer Sec. 29 of the Factories Act. Select the lifting capacity depending on the maximum load to be lifted. Verify its test certificate. Check for slipping of load, jamming of links and free operation. The chain should not come out of pulleys. It is better to lubricate before every use. It should be tested periodically by a competent person (see Rule 60, and Form No. 10, GFR). The anchorage should be strong and rigid. It should be checked for cracks, wear and tear, elongation etc. Opened out hooks and tampered block/puller should not be used. No cannibalising should be done on chain pulley blocks.

See Chapter-Vm, Rule 55, 56, 74, Schedule-1 and Forms V to X of the BOC Workers Central Rules, 1998, for statutory details. See subsequent Part 6.5 and Part 7 of Chapter-28 for further details.

Winches : Safe working load with gear arrangement should be marked on the winch stand. A winch should be placed on a firm base, properly anchored and should not be overloaded. Brake, ratchet arrangement, gear and pinion, meshing, wire rope and its clamping, rope drum and tie rods should be checked before every use. Tie rod should be adjusted to prevent clutch arrangement to slip. Ratchet arrangement should be kept in position while hoisting a load.

See Rule 59 of the BOC Workers Central Rules, 1998, for statutory details.

Hoists : Refer Sec. 28 of the Factories Act. Design should be as per standard code. Outdoor hoist towers should be erected on firm foundation, securely braced, guyed and anchored. Ladder way should extend from bottom to top. Hoist shaft (way) should be enclosed with rigid panels or fencing at all landing platforms, access or where any person is liable to be struck by any moving part. The shaft enclosure, except at approaches, should be of 2 mt (minimum I mt) height above the floor or platform to prevent any person falling down the hoist way. Hoisting engine or motor should be capable of controlling the heaviest load. When the cage or platform reaches its highest point, it should be stopped automatically (no overrun).

Hoist platform or cage should be capable to carry the maximum load. It should have a safety gear to hold it if the rope breaks. At the ground floor coil springs should be provided to arrest any accidental fall. Cage or platform should have toe-boards or enclosures to prevent fall of material inside. Counterweights should run in guides. Interlock door should be provided where any worker has to enter the cage.

Notices of carrying capacity (weight/ persons) should be displayed.

Factory hoists/lifts should be thoroughly examined by a competent person at least once in 6 months with report in Form No. 9 (Rule 58, GFR). See Rule 65 & 78, Form VI of the BOC Workers Rules, 1998 for more details.

Derricks : They are of two types : Stiff-leg derricks and Guy derricks.

Stiff-leg derricks should be erected on a firm base to withstand the weight of the crane structure and the maximum load. Masts should be prevented from lifting out of their seating. The jib length should not be altered without consulting the manufacturer. Counterweights should be so arranged that they do not subject the backstays, sleepers or pivots to excessive strain. Electrically operated derricks should be properly earthed.

In case of wheels-mounted derricks the correct wheel distance should be maintained by a rigid member and struts should be provided to give support if a wheel brake fails or the derrick is derailed.

The mast of guy derricks should be supported by six equi-distance top guys and the guy spread angle from the mast should be less than 45° from the horizontal. The restraint of the guy ropes should be ensured by fitting stirrups or anchor plates in concrete foundations. Guy ropes should have a device to regulate tension. Pins and bearings should be lubricated frequently. When not in use, the derrick boom should be anchored to prevent it from swinging..

The derrick should be tested by a competent person and should not be overloaded. The mast, guyropes, wire ropes, swivel hook, rope clamps etc. should be checked before erecting the derrick. Welded or bolted joints/parts should be checked for crack, defect and tightness.

See also Rules 67 & 68 of the BOC Workers Rules, 1998.

Gin Poles : They should be straight, made of sound metal or straight timber without knots, of sufficient strength and adequately guyed and anchored. They should be adequately fastened at their feet to prevent displacement. Before their re-erection, the pole, ropes, guys, blocks etc. should be inspected and tested under load.

Cranes (Fixed & Mobile) : Refer Sec. 29 of the Factories Act and Rule 60, GFR.

The crane capacity should be ascertained and brakes checked before lifting a load. Mobile crane should be parked on hard soil and not near any pit or excavation.

Safe working load of any crane depends on (a) condition of the ground (b) boom length (c) inclination of boom to the vertical (d) radius of rotation while lifting the load (e) out rigger blocked or free and (f) ' operator's skill.

The safe working load should be displayed in the crane. It should be derated (lowered) due to defects in welding, bend in angle, bracing and conditions of clutch, brake etc.

Devices should be provided to prevent load being moved to a point where the corresponding safe working load of the crane would be exceeded.

Standard signalling code, understood by the operator and trained signalman, should be followed. See Fig. 15.1 of Chapter 15. The crane operator shall respond to signals only from the appointed signaller, but shall obey a stop signal from anybody.

Tag lines should be used while hoisting heavy and bulky load. The crane and its parts (brakes, boom, hook, wire ropes, pulleys etc.) should be checked regularly and maintained in good condition.

The load should not touch the boom and the boom should not touch any live electric line or structure. Quality of packing should be checked before lifting. Nobody should stand below the boom or load. The operator should be able to see the hook and the load, should keep his windshield clean for clear vision and deck clean of any oil, mud or dust.

When the hooks are lowered to the lowest point, at least two dead coils should remain on the rope drum. Makeshift methods to increase the capacity of a crane are unsafe.

During storm, the hook block should be anchored firmly and swing lock be released. At the end of work, the load should be removed from the hook and the hook should be raised to the maximum height.

The mobile crane should have horn, head lights, side lamps, rear and stop lights and flashing direction indicators. Jib crane should keep the job lowered while travelling without load.

While travelling up a slope, the load radius should be decreased and while travelling down, that radius should be increased. Constant watch on the radius is necessary while travelling on uneven surfaces.

Air pressure in the tyres should be equal, otherwise tilting is possible. .

While operating tower cranes, wind loads should be considered and trained operators should be employed to sit in cabs at height. Wind speed indicator should be provided in the driver's cab.

Where two or more cranes work side by side, direct communication system should be provided in the cab to alert the other driver about danger zone. Minimum distance between two approaching cranes should be maintained by limit switches.

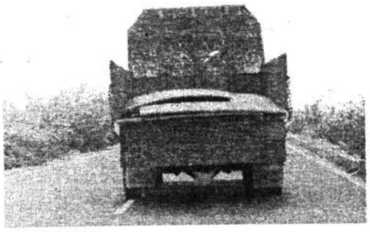
See Rule 57, 58, 63, 64, 74, 80 & 81 of the BOC Workers Rules, 1998 for other details.

Lifting Ropes, Slings etc. : Safe working capacity of the lifting ropes must be known beforehand. Ropes, slings, rings, shackles, tackles, chains, hooks, swivels etc. should be installed, maintained and inspected as per Sec. 29 of the Factories Act and Rule 60, GFR. Repaired ropes should not be used in hoists.

Where multiple independent ropes are used to lift a load, each rope should be capable of carrying tile load independently.

See also Rule 71 of the BOC Workers Rules, 1998.

4.2 Transport, Earth-moving and Material Handling Equipment:



All vehicles and earth-moving and material handling equipment should I have following general provisions.

They should be of good design, sound material and construction, adequate strength and maintained in good working order. Principles of safety and ergonomics should be considered in design and operation.

Operators/drivers should be well trained, medically examined, physically fit and above 18 years of age. They should be competent, reliable and follow the signalling code. Help of authorised signaller must be taken while driving backwards or the view is restricted. They should be protected against weather, dust, load being lifted and possible accidents.

All vehicles should be equipped with proper lights, horns, silencers, power and hand brakes and reversing alarm. Their motors, engines, brakes, gears, chassis, blades, tracks, wire ropes, sheaves, transmission parts and pneumatic, hydraulic systems should be checked daily before use.

The vehicle or machine should not be left unattended with the engine running. Deck plates and steps should be kept free from oil, grease, mud etc. The cab should be kept at least I m away from a face being excavated. Bucket excavators should not be used at the top or bottom of earth walls with a slope exceeding 60°. Gross laden weight, tare weight, maximum axle weight and ground pressure in case of caterpillar should be indicated.

When not in use, the boom should be in the direction of travel and scoop, shovel or bucket be raised and without load. Safe parking place should be provided where more vehicles have to work. Nobody should be allowed to rest or sleep under the vehicle.

Power Shovels (Excavators) : They should be equipped with emergency stop device and two independent locking devices for brake pedals. The bucket teeth should not come nearer the boom than 40 cm. Safe working load of the lifting gear should be displayed in the cabin and its indicator should be fitted. The boom should be prevented from swinging during transport. The boom should not be pulled tight against the emergency stop while supporting a load. The wire ropes should be of specified diameter and construction. The safe operating radius shall not be exceeded.

The shovels should be so operated as not to loose their stability. The driver should see that no person is under or near the raised bucket or grab. When not in use, the bucket shall be kept resting on the stable ground and not hanging. Truck to be loaded should be stationed at 60 cm. or more from the excavator even when it turns. Earthing and fire extinguisher should be provided where necessary.

Bulldozers : While moving uphill, the blade should be kept low. The blade should not be used as brake except in emergency. The blade suspension arrangement, wire rope or hydraulic system should be inspected weekly.

At the close of work, the bulldozer should be left on level ground and before leaving it, the operator should apply the brakes, lower the blade and ripper and put the shift lever in neutral.

Scrappers : The tractor and scrappers should be connected by a safety' line when in operation. Scrappers moving downhill should be left in gear. Scrapper bowls should be propped when blades are being replaced.

Pavers : Guards should be provided to prevent workers from walking under the skip.

Road Rollers : The land should be checked for bearing capacity and general safety before using a road roller. While moving downhill the engine should be in gear. When it is not in use, the brakes should be applied, the wheels should be blocked, the contact should be switched off and the engine should be in bottom gear if the roller is facing uphill and in reverse gear if it is facing downhill.

Pile-drivers : All pile-driving equipment should be of good design and construction and properly maintained. Ergonomic principles should be considered. Pile-driving should becarried out under the supervision of a competent person. Underground services should be located and rendered safe before starting piling. Pile drivers should be firmly supported on sound foundation. If necessary, they ' should be guyed also. If two pile-drivers have to work nearby, they should be separated by a distance at least equal to the longest leg.

If electrical conductors are in proximity, they should be made dead. When leads have to be inclined, they should be counterbalanced and tilting device should be secured against slipping. The hoses of steam and air hammers should be securely lashed to the hammer so as to prevent them from whipping if a connection breaks. Overturning of a pile-driver has to be prevented. Out coming of the rope from the top pulley or wheel and missing of hammer from the pipe should also be prevented.

Pile lines and pulley blocks should be inspected before the beginning of each shift. Only trained operators should be employed. Use of suitable signals, ear protectors and safety helmet is necessary. Piles should be prepared at a distance at least equal to twice the length of the longest pile from the pile-driver. When not in use, the hammer should be blocked at the bottom of the leads.

When pile-drivers are working over water, a suitable boat should be kept readily available at all times. Whistle, siren, signals, fire fighting equipment and sufficient sheaves should be provided, the weight of machinery should be evenly distributed and watertight compartments should be provided with siphons to remove water seepage.

Mobile Asphalt Layers and Finishers : The mixer elevator should be within a metal enclosure with a window for observation, lubrication and maintenance. Bitumen scoops should have covers. The sprayer should have fire resistant shield with an observation window. Non-foaming products are preferable. Reflective jackets should be provided to workers working on public roads.

The fire extinguishers are necessary near spreader and others in readiness. No naked flame should be used to see the level of asphalt in the tank. Thinners should not be heated on open flame. Inspection doors should not be opened if there is any pressure in the boiler.

If a burner flame is extinguished, the fuel supply should be cut off and the heating tube should be thoroughly blown out by the fan to prevent backfire.

See Chapter-X, Rules 88 to 95 of BOC Workers Rules, 1998, for statutory details of the above equipment.

4.3 Plant Machinery, Equipment and Hand Tools :

For figures and pictures see Chapter-17.

All such machinery, equipment and tools should be of good, ergonomic and safe design, maintained in good working order and operated .by trained operators with necessary personal protective equipment. Safety instructions from manufacturer and safe operating procedure should be followed.

Power driven equipment should be properly earthed, stop switch provided in close proximity, adequately guarded, speed regulated and when not in use, switched off (de-energised) and isolated before any major adjustment.

Concrete Mixtures : All gears, chains, rollers and open revolving blades should be guarded or fenced. Hopper should be protected by side railing to prevent workers from passing under the skip. Hopper hoisting wire rope, brake, skip hoist clutch and blocking (fixing when raised) device should be checked and adjusted regularly. Double earthing and insulation of electrical part is necessary. Before allowing a person to enter the drum for cleaning or repair, electrical connections (fuses) should be removed.

Concrete bucket towers and masts with pouring gutters or conveyor belts should be erected by competent persons and inspected daily. The winch operator should be able to see the filling, emptying and lowering of bucket, otherwise a banks-man should direct the operator. Guides for bucket should be correctly aligned to prevent the bucket from jamming in the tower.

Structure or scaffold carrying a pipe for pumped concrete should be strong enough (factor of safety 4 or more) to support a filled pipe and all workers on it. Such concrete carrying pipes should be securely anchored at the ends and at curves, provided at top with air release valves and securely attached to the pump nozzle.

Concrete Vibrators : Vibrating unit should be completely enclosed and belt be guarded. Electrical vibrator should be protected by overload relays and earthed. Cable length should be sufficient. Needle load should be firmly locked. Needle inner core should be lubricated.

See Chapter-XI, Rules 96 to 107 of the BOC Workers Rules, 1998 for Concrete Work.

Pneumatic Compressors: Testing by a competent person is necessary. Air receivers should be equipped with a .safety valve, pressure gauge, drain cock and openings for inspection and cleaning. It is safer to provide a PRV, a stop valve and an oil separator between the air receiver and the compressor.

Compressors should be equipped with an automatic device to control the safe discharge pressure,, a quick release valve and suitable arrangements to prevent or remove contamination in a confined space. Where explosive gas mixture may be formed in compressor, it should be protected against sparking.

Water flow should be ensured in water-cooling jackets. Inter and after coolers should be able to withstand the maximum pressure in the air discharge piping. Such piping should be provided with a fusible plug and insulation to protect workers against burns and fire risks.

Where stop valves are installed in air-discharge piping, they should be easily accessible for inspection and cleaning and one or more safety valves should be installed between the compressor and the stop valve.

Pneumatic Tools : Operating triggers on portable pneumatic tools should be so placed as to minimise the risk of accidental starting of the machine and so arranged as to close the air inlet valve automatically when the pressure of the operator's hand is removed. Air hoses and their connections should be equipped with safety clips or retainers to prevent dies and tools from being accidentally expelled from the barrel. Before any adjustment or repair, power should be disconnected and pressure in hose lines be released.

Cartridge-operated Tools : Preferably low velocity tool should be used. Such tools should have a cover (guard) which cannot be opened without rendering the tool inoperative, devices to prevent from accidental firing, to prevent firing if the muzzle is not pressed and to prevent firing if it is not perpendicular to the working surface.

The recoil should not be capable of injuring the user. The tool should be inspected for all safety devices and to see that the barrel is unobstructed.

Cartridge-operated tools should not be stored or operated in explosive atmosphere. When not in use, it should be kept in its special container for the purpose of safety.

Electric Tools : Portable electrical tools' should be operated at low voltage and with ELCB to avoid risk of shock. The tools should be properly earthed with metallic cases. All insulated or double insulated tools need not be earthed. Periodic inspection and maintenance should be carried out by a competent electrician. Proper fuse and insulated handle are necessary.

Hand Tools ; They should be tempered, dressed or repaired by a competent person. Cutting edges should be kept sharp. Heads of hammers and other shock tools should be dressed or ground as soon as they begin to mushroom or crack. When not in use or while carrying or transporting, they should be kept in suitable containers.

Insulated or non-conducting tools should be used near live electrical installations. Non-sparking tools should be used near flammable vapours.

See Part 3 of Chapter-17 for more details.

Conveyors : Conveyors should be smooth running. Nip between tight belt and pulley/roller and other transmission parts should be guarded. If they are not entirely enclosed, at cross over places, bridge with hand-railing should be provided. Emergency stop-devices (e.g. cord or cable) should be easily accessible. Stop buttons should be provided at drive and take-up ends. Where two or more conveyors operate together, control devices should be so arranged that no conveyor can feed on to a stopped conveyor. When a conveyor is discharging into a bunker or hopper, the feeding conveyor should be provided with an overload switch.

Screw conveyors should always be kept covered. The cover should not be opened without stopping the conveyor.

See Part 3.6 of Chapter-15 for more details.

Crusher Plants : They should be located away from construction area to keep away dust, sand, gravel, noise and vibrations. Extra isolation switch should be provided to prevent accidental starting during repair or maintenance. Electrical motors, switches and instrumentation should be dust and moisture proof. Access roads to the crusher hopper and screens should be cleaned by water spraying. Power cables should be laid underground or at safe elevation. All equipment, plant and machinery should be cleared daily of dust and sand.

Power Generators: They should be housed in a concrete room or insulated area to minimise noise effects. Silencers and exhaust pipes should be provided. Extra isolation switch should be provided to avoid accidental starting during maintenance.

Engines : Maximum safe speed should not be exceeded. Remote control device should be provided to stop or limit the speed. For internal combustion engines, exhaust ventilation should be provided and while fuelling, spark should be avoided and fire extinguisher should be kept ready. Secondary fuel tank should be provided outside the engine room.

Silos : Silos should be erected on sound foundation and capable of withstanding stresses without any deformation of walls, floors and other load-bearing parts.

Safe means of access (stairs, fixed ladders or hoists), quantity/level indicator, notices, blockage remover and fire extinguishers should be provided.

In silos where explosive mixtures are possible, all electrical equipment and hand lamps should be flameproof, non-sparking tools should be used and explosion vents should be provided in the walls at safer points.

Before allowing workers in a silo, work permit should be made, charge (filling) opening should be closed and safety belt with lifeline in the hands of another person outside, should be provided if they have to work on loose material.

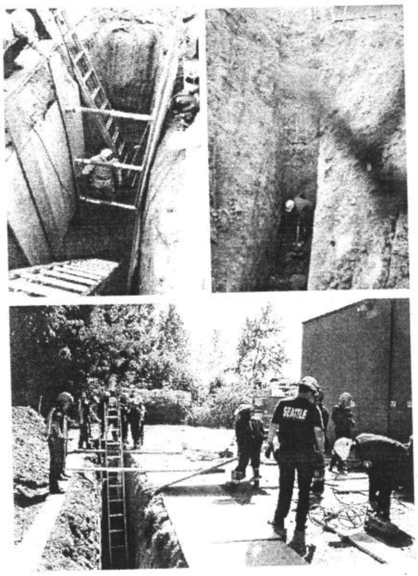
5 UNDERGROUND WORKS

Underground work includes excavations in surface soil or rock, drilling, blasting, trenching, shoring, strutting, tunneling, piling, shaft finking, haulage and underground pipelines. It requires due considerations of underground lighting, ventilation electricity, dust control, inrush of water, oil or gas and continuous safety of people at work. Some provision are explained below:

See Chapter-XIII, Rules 119 to 168 of the BOC Workers Rules, 1998, for excavation and tunneling works including warning signs and notices illumination, stability of structure, pilling, shoring and bracing, safe access, trenches, tunnelling operation shafts, pneumatic tools, inflammable oils, coupling an hoses, storing of oil and fuel underground, use of gases underground, water for fire fighting, flooding, steel curtains, exposure limits of chemicals, ventilation, a locks, man-locks, medical lock, emergency generated etc.

Similarly see Chapter-XXIU, Rules 214 to 222 (the same rules for piling.

5.1 Excavation:



Foundation or underground support is required for most of the constructions and method of reaching earth or rock stratum suitable for foundation is excavation. It may be with or without dewatering the site and out of many methods a suitable method of excavation should be selected.

General precautions for any excavation or underground work are : survey of hazards of fall of persons, soil, material etc., inrush of water, oil, gas etc., adequate lighting and ventilation to supply fresh air inside, controlling gas, vapour, dust etc. within safe limits, fire precaution, safe means of access, stability of the ground, position of public utility services such as electric or telephone cables, water, gas or sewers line etc., effect on adjoining building, structure, roadways, bridges etc. A competent person should make this survey and give permission to work.

If necessary, isolation of underground utility services should be effected by due permission or otherwise be protected. Chemical waste and contamination should be safely removed.

No load, vehicle or material should be moved or stacked near the edge of excavation unless shoring or piling is done to prevent the sides from collapsing. All support work such as props, wedges etc. should be regularly checked for deflection or distortion. All sides should be fenced by barrier at least up to 1m and a danger notice and red signal and light be provided.

Sides of all excavation must be sloped to a safe angle not steeper than the angle of repose of a particular soil. See Table 21 of Chapter 32 for such angle of repose.

Cutting shall be done from top to bottom. No undercutting of side shall be allowed. In narrow trenches a ladder should be extended from bottom to top and I m above the ground surface. Erosion of soil over excavated pits, trenches etc. should be prevented from running water by dewatering pumps etc. Road barrier at a distance should be provided if road is to be blocked. Helmets and gum-boots should be given to all workers working inside.

In large scale excavations for dams, huge buildings, highways, railways etc., accidents occur mostly due to the vehicles, dumpers, trucks etc. Therefore such vehicles must be checked for warning sirens, horns, lights, signals, reverse alarm etc. Rules of driving should be enforced. Sufficient lighting should be provided for night work.

5.2 Drilling, Loading and Blasting:

Drilling and loading are required before blasting.

Before starting drilling, any presence of unfired explosives should be carefully checked. No drilling should be allowed in the butts of old holes. Before drilling, loose or disintegrated rock should be removed by hand tools or pneumatic jack hammers to protect drillers against falls of material. Where this is not possible, a protective canopy or overhead screen should be provided.

Holes are drilled by pneumatic hand-hold drills to a specific pattern. Compressed air hoses should have self locking couplings. Drillers should wear helmet, hand gloves and gumboots.

After checking the drilling pattern and depth, the drilling crew is withdrawn from the site with all drilling equipment and accessories. The blasting foreman will check all the holes to be loaded by explosives and detonators for blasting. Transportation, storage, handling and use of explosives are governed by the Explosives Act and Rules. See Part 3.3 & 3.4 of Chapter-28. No smoking or open flame is allowed in explosive loading area. All the workers from this area are withdrawn to a safe place. Only suitable battery lamps should be used during loading shot holes.

No holes should be loaded except those which are to be fired in the next round of blasting. Holes loaded during one shift should be fired in the same shift. Diameter of the hole should be at least 3 mm more than the dia of the cartridge. To avoid misfires, the detonator should be completely inserted length-wise in the cartridge and fastened in such a manner that it cannot be pulled out accidentally. The cartridges are not forced into the holes. Cap crimpers of proper design should be used for crimping the blasting caps into fuse. A knife or teeth shall not be used for this purpose. Intensity of charge to be loaded must be well calculated and safe enough to prevent damage to nearby structures due to shock and vibration resulting form explosion.

Tamping of cartridge in the hole is done by a wooden (or non-sparking metallic) stick gently. If dynamite is to be removed from cartridge, loose dynamite should not be tamped. Primer -shall never be tamped. During tamping care should be exercised to avoid injury to fuse or cap wires. The holes are filled with clay and sand sticks at the top. Detonators' wires should not be damaged or pulled out.

Then the continuity of the entire circuit is checked by a blasting circuit tester and the resistance of the circuit is also measured. No other electric circuit should be allowed in that area or it should be de-energised. Radio, TV and Radar transmitters can detonate electric cap. Hence minimum safe distance should be maintained. The lead wires are connected to the exploder whose firing switches are kept 'open', locked and keys with the blasting foreman. The surplus explosives/detonators are returned to the magazines.

Then follows the warning procedure. 'Warning' and 'All clear' signals should be established and made known to all concern. Trained persons are posted at all approaches with red flags to stop all traffic and by passers.

The blasting foreman, then, sounds a warning siren to drive away all persons from the danger area and not to allow anybody to enter in the blasting area. After being satisfied with the readiness of blasting, the blasting foreman will fire the shots by closing the switch of the exploder. After dispersion of gases and dusts, the foreman will return to the area and check for any misfire.

Misfire can be minimised by using good quality explosives, testing each electric cap with a blasting galvanometer before loading or by testing the complete circuit before firing. The safest way to deal with misfire is to re shoot it by new primer. If there is no misfire, then he gives 'All Clear' signal and allows the removal of blasted materials. Loose rock should be scaled down.

Haulage i.e. pulling and shifting of material after blasting is carried out manually or mechanically. Vehicles (train or trucks) should have head-lights, tail-lights and loud horns. Hauling by winch should be done under the supervision of a competent person. Workers should not be transported along with the material.

Blasting record should be maintained. Date and time of blast, number of holes, type of explosives and detonator used, amount of charge per hole, firing pattern and sequence should be recorded.

5.3 Shoring and Underpinning:

Shoring and underpinning are required to stop settlement of a weak foundation, to strengthen the foundation to carry added loads, to provide support because of adjacent operations and to prevent deterioration of the foundation materials.

Shoring refers to removal of temporary supports after completion of job and underpinning refers to providing permanent supports which remain in place even after completion of job.

Shoring requires skilled workers and cordoning off the area due to hazardous nature of the job. It is to be carried out under constant supervision and control of qualified and experienced engineer. The jack, needles and temporary supports should be of adequate capacity and strength to raise the structure.

Types of shores available are raking, flying, needle beam and post. The shores and needles to be underpinned must be designed to withstand the anticipated load.

Underpinning is useful to stop settlement of the structure, or to give more support by new foundations to withstand added load of the structure. This work is to be done rapidly, in a limited space and with great care, to the existing structure. Adequate lateral bracing helps obviate the need of underpinning interior walls or columns.

If damage results during underpinning and repairs required, it is best to wait till all settlement and lateral movement are ceased.

Generally two methods are available for underpinning - the pit method and the steel cylinder or caisson method. The pit method is used where new foundation is not to be very deep. In the other method, the steel cylinders of caissons are placed under the existing footings and sunk to the rock. Skilled workers are required due to restricted availability of working space and headroom. The shoring of the column is removed at the end.

5.4 Tunnelling and Shaft Sinking:

Tunnels are required for road-ways and railways through mountain, hydro-power station underground, irrigation of water, drainage, mining of minerals, storage of hazardous Wastes and defence installations (underground shelter) etc.

Tunnelling may be in soft ground (clay, sand, gravel or soft earth) or in rock. Soft ground tunnelling is carried out by fore poling, needle-beam and timber, liner plates, shield and liner plates and plenum process or compressed air-lock. Rock tunnelling is carried out by drilling, blasting, mucking or by machines which may be full face boring machine or the header with rotary milling head on a telescopic boom.

Safety measures include well maintained equipment and tools, their testing by competent persons, speedy removal of debris, refuse and trash, safe and adequate walkway, proper drainage and water pumping if required, good lighting, use of helmet, gumboots and goggles by the workers, jumbo platform with guard rails and toe-guards to work near the entire face of the tunnel to be drilled, pneumatic drills with pusher legs, wet drilling for dust control, pneumatic coupling with self locking couplings, separate transport vehicles for explosives and detonators and their separate magazines, safe handling of explosives and detonators, avoidance of spark, no smoking in explosive area and all precautions mentioned in foregoing Part 5.2 for drilling, loading, blasting and haulage.

After blasting, rock falls can cause major accidents. Therefore inspection of walls and roofs, scaling of loose rock, bolting and supporting of weak spots, checking of weak seams and planes by a hand hammer and supporting of roof and sides are essential.

Mechanical loading of muck and haulage are required for speedy construction in tunnel. Muck (dirty thing) cars should be loaded evenly and not piled above the sides. Vehicles in tunnel should not run overloading and overspeeding. Rail-tracks should be safe and sound. Smokeless locomotives should be used. Dump cars should be with locking device to prevent accidental tipping.

When tunnelling is done through a shaft (vertical rod or stem), the tunnel musk is hoisted through die shaft and brought to surface for disposal. Hoisting machines should have automatic brakes to stop and hold the conveyance (cage or car) if the hoisting power fails. It should have a depth indicator. Rules for hoist/lift should be followed as mentioned in foregoing Part 4.1.

Mechanical ventilation is necessary in all tunnelling work to supply fresh air to the working crew and removal of dust, fumes and gases including methane, CO, etc. Rock dust containing silica and quartz may cause silicosis. Ventilation ducts should be airtight and should have reversible duct blowers to operate in both directions.

The tunnels are lined with plain or reinforced concrete or steel forms to support the surfaces and to prevent any rock fall. Scaffolding carrying pipeline of pumped concrete should be strong enough. The workers should wear face shield or safety goggles.

Safety precautions for shaft sinking are mostly same as stated above. The shaft which is not sunk through solid rock should be cased, lined or otherwise made safe. Workers should be provided with cradles from which they can work safely. The shaft top should be protected by fencing or guard-rails, toe-boards and gates. Means of escape and ladder from bottom to top should be provided in addition to any mechanical means of ingress and egress. Winches at shaft tops should provide easy replacement of bucket. All landings in shaft should have gates that close the opening to a height of at least 2 mt.

All shafts of over 30 mt in depth should have an adequate head frame strong enough to withstand the maximum load. It should be open steel work, fire resistant and protected against lightening.

Shafts should have a signalling system that warns the hoisting man when a conveyance passes beyond the safe limit of travel. The signal code should be posted in the hoisting machine room and at each landing.

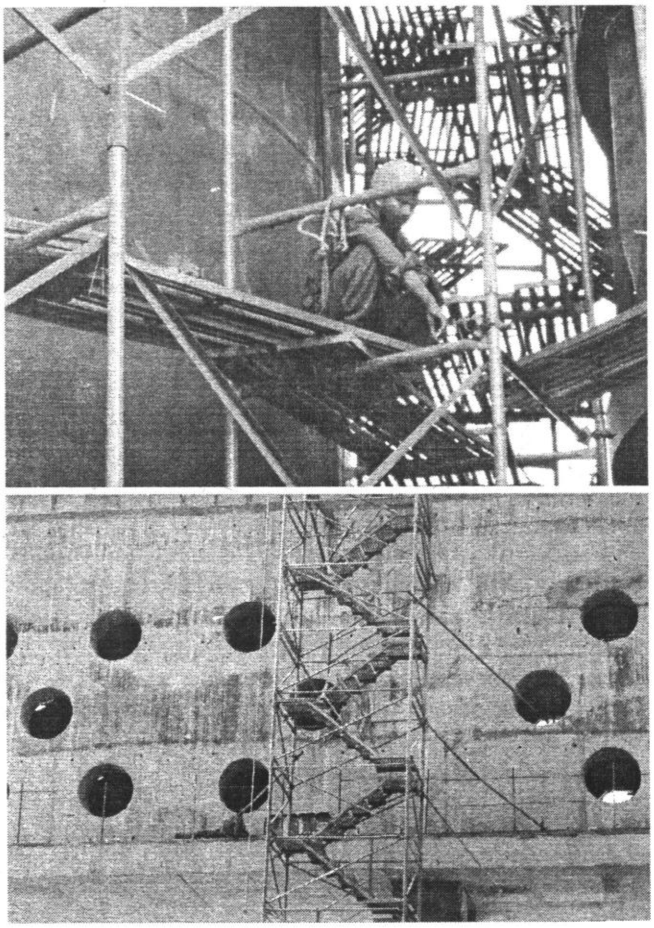
No combustible material or structure should be allowed within a shaft, tunnel mouth, engine house or fan house. Lubricating oils, grease and rope dressings should be kept in closed metal containers and away from shafts. Electrical installations in shafts and tunnels should comply with rules and regulations. Lightening arresters should be provided on the surface. Emergency lighting to function for a long time (to escape safely) should also be provided.

6 ABOVE GROUND WORKS

Most of the construction works in the form of concrete, steel, wood or mixed structure are found just on the ground. Basic requirements to work at height as the work proceeds, are scaffolding, ladders, staircases, centring, formwork, wall and floor openings, structural steel work and machinery and equipment for the movement of material and men.

6.1 Scaffolding, Ladders and Staircases:

For figures and pictures see Chapter-16.



See Chapter XV, Rules 172 to 174 for ladders and Chapter XIX, Rules 188 to 205 for scaffold, of the BOC Workers Rules, 1998. See Part 7 of Chapter-28 for their details.

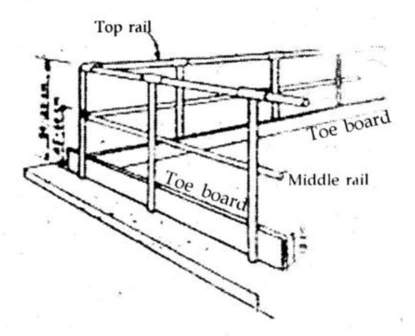
6.2 Structural Frames, Formwork and Concrete Work

All such works require trained workers and the supervision of qualified and experienced engineer. Temporary work (formwork, slip form, shuttering, false work, shoring etc.) should be safe enough to withstand loads on it and working platforms, ladders, bracing etc. can be attached to it. Safety of workers from temporary, unstable- or weak structure has to be foreseen.

See Chapter XVII, Rules 181 to 185 for structural frame and framework and Chapter XI, Rules 96 to 107 for concrete work of the BOC Workers Rules, 1998. See ' Part 7 of Chapter-28 for their details.

6.2.1 Erection and Dismantling of Steel and Prefabricated Structures

Safety of workers should be ensured by providing sound scaffolds, platforms, ladders, gangways, boatswain's chairs, safety belts, fall arrester nets and lifting appliances including power driven mobile working platforms. All such platforms must have safety railing (at least 1 mt high), hand rails and toe-boards. Free end of the safety belt must be tied with a fixed and strong support. Helmets, goggles, gloves, aprons and other equipment should be worn by the workers. Floors, stairs and platforms should be dry, clean and non-slippery. This can save many injuries.



Hooks for lifting and transporting prefabricated parts or material should be of self-closing type and withstand load and stresses. Precast concrete parts should be allowed to set and harden for its full strength. Stores and racks of steel and prefabricated parts should be on firm ground and so arranged as no part should fall or overturn. Lifting appliance should be suitable and tested at 20% more load. Tongs, clamps etc. should be capable of securing grip and marked with maximum permissible load. Lifted structure and wall units should be so placed that they do not fall by wind, jerk or other factors.

Adequate instructions should be given to the workers for safe erection. If due to high wind, rain, snow or reduced visibility, it becomes unsafe to work, the work should be interrupted. Parts to be erected at a greater height should be assembled on the ground. While lifting prefabricated parts, area underneath it should be barricaded. Steel trusses being erected, should be firmly shored, braced or guyed until they are permanently secured in position and no workers should be allowed to work under them at that time. A boom or any moving part of a crane (including the load lifted) should not touch such trusses. In absence of such precautions, six workers died in one accident 'when trusses fell down on workers working underneath. No load-bearing structural member should be weakened by cutting, drilling etc. Open-web steel joints should be directly placed in position and secured against dislodgement.

6.2.2 Cast-in-situ Concrete Structures :

The planning of construction of cast-in-situ, large span and multi-storey concrete structures should provide information on specifications of materials to be used, methods of safe placing and handling, reinforcement design and load-bearing calculations. During construction, a daily progress report should be maintained, stagewise erection procedure should be prescribed, defects watched continuously and loads should not be dumped or placed on setting concrete.

6.2.3 Wall and Floor Openings :

Walls should be on sound footing, perfectly vertical, properly joined and of sufficient thickness for strength and load-bearing. Brick joints should be properly aligned, cemented and pointed if required. Plastering and colour coating give extra protection. Support of the wall under construction should not be taken but a scaffold should be used. Doors, windows, ventilators and other openings in walls should be, provided as per requirement and drawing. As per Rule ISA, GFR, they should be at least 15% of the floor area. Bottom of a window should begin within 1 mt from the floor.

Floor construction uses a variety of material depending on choice. Earth filling with cement or cement concrete is necessary for strength. Wooden planks, steel grate (grill) or plates, tiles, stones, marble, cement concrete, asphalt etc. are some of the flooring materials.

Floor openings are required for erection of hoist or lift way, tank, vessel or reactor, piping etc. Till these floor-gaps are not occupied by their proper fittings, they pose danger of falling from height. Therefore Section 33 of the Factories Act requires that all such floor openings should be securely covered or fenced. If any gate is provided at any landing platform, it should be kept locked (not simply closed and openable) when any person has to work near it. In absence of such unlocked gate, a worker- fell from a 30 mt height and died on the spot.

Temporary floors should be securely covered with close planking or other covering until it is replaced by a permanent floor. Parts of protection should only be removed to the extent required for the progress of the work. In skeleton steel structures, permanent floor filling should be installed as the erection progresses.

6.2.4 Formwork and Slip forms:

Tubular steel frames used as staging to support concrete form-work should have a safety factor of at least 2 and be used as per manufacturer's recommendation. Struts and/or diagonal braces must be in proper position and secured for frames to develop full load carrying capacity. As erection progresses, all connecting devices should be in place and fastened for full stability of joints and nuts. As height increases above two tires, suitable planking should be used as a working platform. During concrete pouring operation, staging system should be constantly watched and corrected if necessary.

Concise procedures to cover all stages of work should be prepared and supervised by a competent person. Foundations should be checked for ground conditions. Drawing or sketch for shuttering should be explained to workers. Shoring should be provided for support and should not be removed until authorisation and the concrete has acquired sufficient strength. Shoring should be braced or tied together to prevent deformation or displacement. Mechanical, hydraulic, pneumatic or vacuum lifting devices should have automatic holding device in case of power failure.

Workers placing reinforcement rods and unloading concreted above the slipform platform should wear safety belts and lanyards to protect from falling. Slipform floor where reinforcement rods are being lifted should have temporary barricades. While lapping/ joining vertical reinforcement rods, the projections should be tied to prevent their falling off inadvertently.

6.3 Structural Steel Work and Erection:

A fabrication yard should be well away from a rail-track, road, overhead transmission, lines, boiler house and source of ignition. While unloading structural steel wagons or trucks by crane, wheels should be made stationary by fixing wedges and nobody should stand under a hanging load. While putting heavy structure, supports (props) should be given to prevent toppling. At both ends of a gantry crane, stoppers should be provided. Leather gloves, goggles etc. should be used as per requirement. Portable tools should have guards, proper fuse, earthing and ELCB in power connection. See Part 6.2.3 of Chapter11.

In erection work load should be ascertained for centre of gravity and its transfer at the slinging point. Lifting machines, ropes, slings, tackles etc. should be checked for its good working order and safety. Eye bolts should be provided at correct slinging points while lifting heavy machinery such as motors, turbines, generators etc. No sling should be overloaded. Signalling code should be known to all. Proper tag line should be used for guiding while lifting loads.

Stack of structural members should be such that light members should be at the top and in sequence of erection and not in a position to roll down or slide while handling. Clear passages, should be allowed. Hands should not be jammed against any object. Bolts, nuts, tools etc. should be kept in boxes and not loose on the structure. Vertical column should be tied by 4 guy ropes and only after bracing or fixing, the ropes may be removed one by one. Precautions in placing trusses are explained in foregoing Part 6.2.1. CGI sheet should be lifted manually by proper system. It should not fall. They should be kept tied on top and bolted or stitched ultimately.

6.4 Welding and Cutting Operations :

See Part 7.1 of Chapter 20, and Schedule 24, Rule 102 of the Gujarat Factories Rules.

6.5 Lifting Machinery and Equipment:

For figures and pictures see Chapter-15.

See Part 3.5 of Chapter 15, and also foregoing Part 4.1.

See Chapter VII, Rules 55 to 81 including Schedule 1 and Forms V to X, of the BOC Workers Rules, 1998, for statutory provisions of lifting appliances and gear. This chapter prescribes details of construction and maintenance of lifting appliances, their examination, automatic safe load indicators, winches, buckets, safe working load, operational safety, hoists, means of access, derricks, ropes, heat treatment, vacuum and magnetic lifting gear, attachment of loads, tower cranes and qualification of operator, signaller etc. See Part 7 of Chapter-28 for their details.

7 UNDERWATER WORKS

Work under or over water is required for deep foundation, well sinking, river dredging, underwater pipelines, tunnelling, concreting, cofferdam, floating structure and special operations pertaining to irrigation and marine purposes.

7.1 General Provisions:

Main safety measures necessary are (1) to prevent workers from falling into water (2) to rescue them in the event of drowning and (3) safe and sufficient transport and life saving equipment.

Life buoys, life jackets, manned boats, fencing, safety nets, safety harness and protection from reptiles and other animals are also necessary.

Bridges, footbridges, pontoons, walkways, gangways and workplaces should possess sufficient buoyancy, strength and stability, be wide enough to allow safe movement of workers, free from nails, bolts, knots and tripping hazards, boarded over, lighted sufficiently, be provided with life saving equipment, toe-boards, guard-rails, hand ropes etc., be kept clear of tackle, tools and other obstructions, be made nonslippery by spraying sand, ashes etc., be anchored to prevent run away, be provided with ladders with safety hoops.

Floating structures should have shelters, lifelines, gaffs, ring buoys. Rafts (logs), if used, should be strong enough to carry loads, securely moored and have safe means of access.

Iron decks should be studded with non-slip surface and deck openings should be fenced. Floating pipelines should have safe walkway. No person should enter a hydraulic dredge gear room without informing the leverman and without being accompanied by a second person. Hoist lines, drag lines, buckets, cutter heads .and bridles should be inspected daily. Workers should be embarked and disembarked only at safe and suitable landing places and counted regularly.

7.2 Boats:

Boat used to transport workers by water should comply with legal requirements if any. It should be manned by an adequate and experienced crew and be equipped with life-saving appliances.

The number of persons that can be transported safely should be marked as clearly visible and no more person than that must be allowed.

Tow-boats should have a device to quick release tow-rope. Power driven boats should carry suitable fire extinguishers. Row-boats should carry a spare set of oars. Rescue boats should be properly constructed and of sufficient length and beam to afford stability. For work in tidal waters or fast flowing rivers a powerdriven craft should be provided with a fixed selfstarting device on the motor. When not patrolling, their engines should be run several times a day to ensure full efficiency.

7.3 Rescue and Emergency Procedures:

Buoyancy-aid like life-jackets should be provided to rescue crew. Operatives should not work alone and they should be trained for emergency procedures.

Rule 36, BOC Workers Rules, 1998, requires emergency action plan to handle emergencies like drowning of workers, sinking of vessels, fire and explosion, collapse of lifting or transport equipment, building, shed, structure etc., gas leakage, spillage of dangerous goods, land slide, floods, storing etc. It should be approved by the Director General.

7.4 Well-Sinking:

Shaft-sinking operation for digging well or tunnel pose various hazards like wet and slippery footing, cramped working space, insufficient lighting, unknown weakness in rock or soil, handling of explosives and detonators, hoisting and haulage of muck and accidents due to machinery and mistakes in working methods. Dewatering pumps, shoring machine guarding and control devices, use of personal protective equipment, training and supervision are useful remedial measures. 7.5 Cofferdam:

Underwater excavation is carried out by (1) Pumping out the water if inflow is not excessive (2) Isolating the site by a cofferdam (temporary bund) (3) Sinking caisson (box) with or without compressed air or (4) Chemical consolidation.

The cofferdam is a temporary structure to exclude water from water-logged soil, river or the sea to enable the excavation and construction to be carried out in the dry. The cofferdam can be made out of earth, concrete, sheet piles or sheet cell.

The earthen cofferdam is possible in shallow water with low velocity of current. The earthen bank is constructed 1 mt of the top water level. Due to water seeping and leaking such dam can fail. Therefore constant watch is necessary.

Sheetpiled cofferdam can be constructed by using a floating structure with machinery and crew. All members of floating 'pile-driving crew should be trained to handle boats. The interlocking sheet piles and bracing in a cellular form are placed through water. Fuel tanks below deck of a floating pile-driving equipment should be vented to the outside air with flame arresters. Workers handling piles should wear leather gloves. A competent person should constantly supervise.

After erecting the cofferdam, inside water is pumped out. The excavation is done in dry soil up to a sound strata, the foundation is laid down and the structure is built. The cofferdam is dismantled thereafter.

7.6 Caissons:

A caisson is a box type structure to be used as a part of foundation. Unlike cofferdam, it is a permanent structure and forms an integral part of the bridge or building foundation.

The caissons are of three types (1) A box caisson which is closed at the bottom but open at top to the atmosphere (2) An open caisson which is open at both the ends and (3) A pneumatic caisson which has a working chamber with roof in which air pressure is maintained to prevent the entry of water and soil into excavation.

The box caisson is possible where no much excavation is required under water. The box is prepared of concrete or stone masonry 6n a dry dock, floated out to the location of sinking, sunk at the place of foundation bed and filled with mass of concrete or sand.

The open caisson is a hollow cylinder or rectangular hollow shaft made of timber, masonry or RCC. Its bottom edge is V-shaped (pointed) and known as cutting edge. On reaching foundation level, mass concrete is placed to plug the cell after which any water is pumped out and further concrete is placed to form the final seal. Such open caisson is possible on soft soil and not suitable on hard or irregular rock surface.

Where piles driving or open caisson is not possible, the pneumatic caisson is created by compressed air to drive water out of the working space for men and voids in material which is being excavated and thereby making the inside dry for easy working. More than 1 m" or 285 litres of fresh air per minute per person should be supplied in the chamber at a pressure below 2.5 bar. During compression initial pressure is kept about 0.25 bar until it is ascertained that no person is feeling discomfort, and thereafter it may be raised at a rate not exceeding about 0.5 bar/ min. Standby power should be available to the air compressors. To improve the working condition and to reduce the incidence of caisson sickness, the air should be warmed in cold weather and cooled in hot weather. In tropical climate, it should be dehumidified to keep the wet bulb temperature below 25 °C. In air and water tight chamber, openings for men and materials are provided at top in the vertical shafts with air-locks. The shafts (and openings) extend from the roof of the caisson to a level well above the water level outside. The man-lock should be of sufficient size and equipped with pressure gauges, communication system and man-lock attendant.

Every caisson, shaft, working chamber, medical lock and man lock should have a minimum internal height of 1.8 mt. The door between the working chamber and the man lock leading to a lower pressure should be kept open when any person is working inside and the lock is not in use. Air supplied to the caisson from a compressor should be clean and non-polluted. All air lines should be in duplicate and with non-return valves to prevent the air escape from the chamber if pressure in the lines fails. There should be a standby compressor for emergencies and two separate power supplies for each compressor. There should be two independent sources of electrical supply for lighting. Exhaust valves should be provided on chamber for clearing the air when necessary. Reliable means of communication such as bells, whistles, telephones etc. should be maintained at all times between the working chamber and surface installations. An adjustable safety valve should be fitted on the outside of the bulkhead to a separate pipe leading from the working chamber through the bulkhead to the outside air. Every caisson and shaft containing flammable material should have water lines, hose connections and fire extinguishers.

In all tunnels 5 mt or over in diameter or height, a well-guarded overhead gangway should be provided from the working surface to the nearest airlock with an overhead clearance of at least 1.8 mt.

Effects of air pressure on human body may be light (known as bends) or severe resulting in paralysis or death. Pain in ears, stomach and joints (like rheumatism), profuse cold perspiration, dizziness, giddiness, double vision, incoherence of speech, heat and feeling of resistance to move owing to density and pressure of air are reported. Rapid lowering of air pressure (decompression) causes severe effect as the nitrogen comes out from the body fluid (mostly blood). Therefore it must be ensured that the depressuring must be carried out slowly.

The workers should be physically fit (not fat, and with normal lungs, kidneys and good heart rate), above the age of 20 and medically re-examined at least every 2 months or earlier. A first-aid box should be kept in the working chamber.

To counteract the effect of cold, the air-lock should be warmed, the men coming out (emerging) should be given hot drink and they should dress warmly. The best cure for 'caisson disease' is recompression with slow decompression. This is achieved by putting the patient in a medical air-lock for this purpose. The trained lock keepers and medical lock attendants should be employed in the works. The medical lock should have two compartments so that it can be entered under pressure.

See Chapter XX, Rule 206 & 207 of the BOC Workers Rules, 1998, for cofferdams and caissons.

8 DEMOLITION

Demolition of very old, life-ended, weak or unsafe construction becomes necessary. Sometimes it is required for a new construction, alteration, addition or repairs on the same site. High risk is involved due to falling or flying material, working at height or on a structure being broken, use of heavy hand tools and heavy blows and vibration or sudden collapse. Not only the workers but the public passing by, have also to be protected. Proper planning, permit, procedure, sequence of work, training of workers and safety supervision by a competent person are some of the basic requirements.

See Chapter XII, Rules 108 to 118 of the BOC Workers Rules, 1998, for demolition. See Part 7 of Chapter-28 for their details.

8.1 Precautions Prior to Demolition :

A definite demolition procedure should be worked after studying the entire structure and carrying out a survey of its drawings, load bearing members, type of foundation, walls etc., chemical contents if any, previous use, structural problems, ground characteristics, condition of roof trusses, type of framing used in framed structure, equipment sensitive to noise, vibration, dust etc., radioactivity, utility or service lines, gas and power lines, joint with or effect on adjacent building, climatic conditions etc. A help of structural engineer is advisable.

A method of demolition should be formulated after above survey and recorded in a method statement after identifying the problems and their solutions.

All electric, gas, water and other service lines should be shut off or safely protected against damage. The plant or building should be isolated from all other plants or buildings.

For protection of the public, all the roads and open areas surrounding the work (i.e. danger or safety zone) should be fenced off (fence height at least 2 mt) and caution boards and danger signs should be displayed in the local language, Hindi and English at prominent places. Unauthorised entry into it shall be effectively controlled. If a swinging weight (ball) is to be used for demolition, width of the safety zone should be 1.5 times the height of the structure. If a clamshell bucket is to be used for demolition, safety zone of 8 mt from the line of travel of the bucket should be maintained.

8.2 Precautions During Demolition :

Only trained workers should be employed (new or unskilled may cause more accidents). They should wear helmet, safety belt, safety shoes, safety goggles and gloves.

A part which would destroy the stability of other parts should not be demolished. To prevent danger, parts of structure should be adequately shored; braced or otherwise supported. Foundation walls serving as retaining walls to support earth or adjoining structures should not be demolished until the adjoining structure has been underpinned or braced and the earth removed or supported by sheet piling or sheathing.

Where a deliberate controlled collapse technique is to be used, expert engineering advice should be obtained. It should be used only where enough surrounding space is available to withdraw men and equipment at a safe distance. Structure not carrying its design load may be pre-weakened before a deliberate collapse, but in such cases the pre-weakening should be carefully planned and dead load should be reduced systematically.

When equipment such as power shovels and bulldozers are used for demolition, type of building, its dimensions and the power of the equipment should be considered.

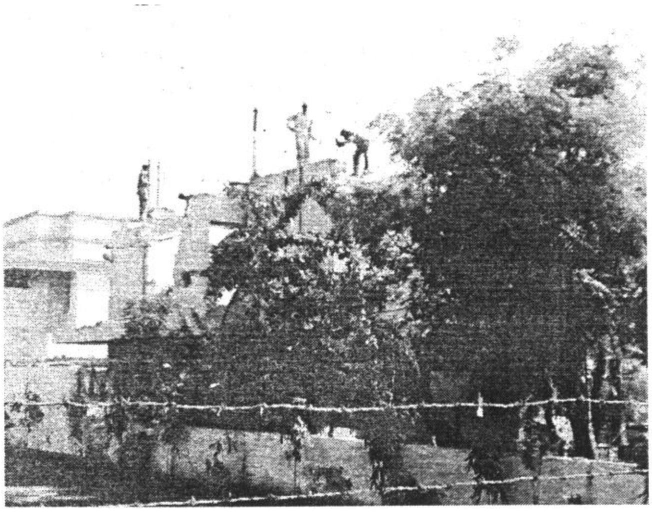
Where explosives are used to demolish key members, the blast protection and safe distances should be agreed in advance. The work should be carried out by experienced personnel in a controlled manner.

Sometimes catch platforms (at least 1.5 mt wide) are provided along the outside of the outer walls to catch falling materials. The outer edge of such platform should be higher than the inner edge (i.e. inclined to wall side) and the platform should be lowered as the demolition work gets lowered. Sequence of Demolition: Glass panels of doors and windows should be removed first. Then loose objects and projecting parts including balconies should be removed. Work should start at the top of the structure and proceed downwards. When work is going on at upper level, workers should not be deployed at lower level. Broken material should not be thrown but lowered safely. It should not be allowed to be accumulated to disturb stability. Dusting should be minimised by watering. Stairs with hand railing should be kept in place as long as practicable to provide access and egress.

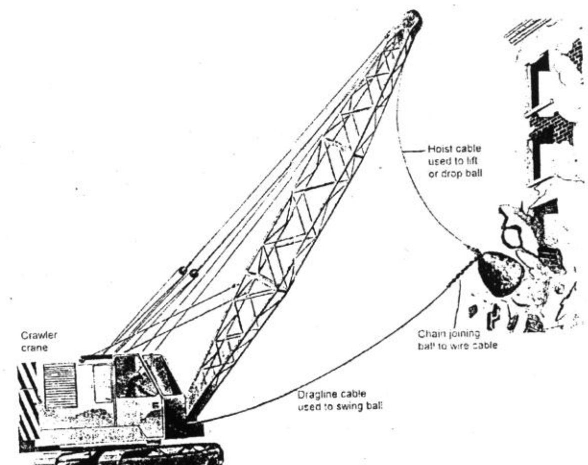
Scaffolds used for demolition, should be independent of the structure being demolished. Travelling mechanical ladders can be used.

AC sheet roofing requires careful consideration of points of support before planning its demolition. A firm ladder resting on such point should be given to workers to climb to the roof. Then they should use a cat ladder or a crawling board supported on ridge to stand and remove the sheet. In no case, they should be allowed to walk or stand directly on the AC sheet. Underneath nearby fall arrester net should also be used.

Walls should be demolished storey by storey and starting from the top. Unsupported walls should be prevented from falling by shoring and, ties.



Starting of demolition from the top level



Demolition by Balling

Floors should be demolished by using planking or walkways to stand or move when it becomes weak to withstand the load. Openings through which material is dropped should be fenced or barricaded.

Tall chimneys should not be demolished by blasting or overturning unless the sufficient open area is available for its safe fall. Workers should not stand on chimney wall. Thrown down material should be removed during breaks in the work or under controlled conditions.

Structural steelworks should be demolished by cutting its parts in such a way that it should not collapse, twist or spring suddenly. It should be demolished tier by tier. Cut parts should not be thrown from a height. They should be lowered safely.

Industrial structure such as a nuclear power plant, hazardous chemical or petrochemical plant or a plant containing a plenty of asbestos material (e.g. insulation, AC sheets) should be demolished only after consulting their respective experts or specialist engineer and taking all precautionary measures against their specific hazards. General rules are as stated earlier.

9 MOVEMENT OF MATERIALS AND MEN

Construction materials being heavy, long or varying in size, pose hazards in handling, loading, unloading and transportation. Railway wagons, motor trucks, tractors, trailers etc. are used depending on the weight, size and distance to be travelled. Training of handling of such materials and use of lifting appliances for them is a basic requirement. Sec Chapter15 and 16 for material handling and working at heights and depths. See Part 6,7,8 and 9 of Chapter28 also.

Some general precautions are as under :

1. For selecting transportation by railway wagons, the route should be surveyed. The material should not foul with any fixed structure object or another wagon while negotiating bend or turn. The material should not project outside and height should not reach electromagnetic field of overhead traction line. Railway rules should be followed. Identification, marking and proper packing are necessary.
2. Motor trucks must have valid RTO permits and efficient brakes, lights, horns, side and reverse signals, jacks, tools etc. They should be in good working condition. Only trained and licensed driver should drive and not the helper or cleaner. While driving an Ethylene oxide tanker by a cleaner, it was dashed against a structure resulting into breaking of the main valve and the whole factory shed and the tanker were burnt into ashes.
3. Drivers should strictly follow the speed limit on highway and inside any factory premises. They should observe utmost care while turning, overtaking, crossing railway level crossing and applying brakes. They should have 'tremcard' while carrying hazardous chemicals.
4. The transport vehicle should not be overloaded. No material should project above or beyond the side panels. Backward projection should not be more than a meter. Bending bars (rods) should not touch the road. Liquid should not be leaking. Lime, cement, gravel or dusty material should not throw continuous dust. They should be covered. Red signals (flag or light) should be displayed on the projected end.
5. Material should be properly loaded considering weight, dimension, centre of gravity of the load, carrier capacity, safety distance and working clearance. Load should be properly packed and lashed. In rainy season, waterproof cover should be provided.
6. Men should not sit on the load or side panels or on the driver's cabin. They should not walk on a moving vehicle.

Necessary fire fighting arrangement should be kept ready. Engine exhausts shall not open near any flammable material. Vehicles carrying highly flammable liquids or gases must have spark arrester on their exhaust pipe. Explosives, detonators and combustible material shall be separately stored with safety precautions. It should not be piled over 2.5 mt height. See Chapter 13 for fire & explosion safety. For electrical safety see Chapter II. See Chapter 28, Part 6.1 and 6.2 for Motor Vehicles Act and Rules.

10 HEALTH AND WELFARE OF CONSTRUCTION WORKERS

For figures and pictures see Chapter-24.

Occupational hazards and diseases relating to construction work are mainly dust hazards (Silicosis due to silica dust, Siderosis due to iron dust, Anthracosis due to coal dust and Cement Pneumoconiosis due to cement dust), noise and vibration, heat and humidity, electricity, hazardous chemicals, work at heights and depths (in a confined space), material handling, lifting machinery, transport vehicles, radiation hazards, biological hazards etc. First-aid boxes and occupational health services at workplace or nearby are most desirable.

10.1 Dust Hazards :

While handling building materials, workers can be exposed to four types of dusts which by inhalation can cause following lung diseases (Pneumoconiosis) :

Silicosis : Silica (SiO,) dust (respirable size 0.5 to 3 micron) causes fibrotic changes, modulation in both lungs, shortness of breath, decreased chest expansion, reduced capacity for work and in advanced case impairment of total lung capacity. The effect is irreversible and no effective treatment is available. It is a notifiable and compensable disease under the law.

The effect of exposure, varies with the concentration of dust, time period, working conditions, body resistance, control measures etc.

Chest X-ray shows a snow storm appearance in lung fields. But it should be confirmed by a history of prolonged exposure of silica dust and symptoms of dry cough, dysponea, chest tightness and difficulty in breathing. Regular medical examination of workers and engineering controls to minimise exposure are necessary.

Siderosis is caused by inhalation of iron dust (Iron oxide). Electric arc welding, dry grinding of iron, buffing, polishing and shot-blasting produce iron dust. It seldom causes serious symptom unless there is coexistent silicosis.

Anthracosis (Coal workers' pneumoconiosis) is caused by inhalation of coal dust. Foundry workers, coal handlers, couple collie, boilermen (sealers), furnacemen, railway firemen, graphite workers etc. are exposed to coal dusts. The first phase (requires about 12 years of work) causes little ventilatory impairment, but the second phase causes progressive massive fibrosis (PMF) resulting in severe respiratory disability and tending to death.

Early diagnosis and change in occupation offers the best hope. Other treatment like chemotherapy should be as per doctor's advice.

Cement (Benign) Pneumoconiosis, silicosis with associated pulmonary tuberculosis, bronchitis and emphysema are possible with cement or cement and free silica dust (e.g. acid resistant cement).

In addition to these respiratory disorders, other health hazards are as under :

Skin	Cement eczema due to alkalinity or presence of chromium Furncles, Pyoderma, Cellulitis, Asbestosis
Vision	Conjunctivitis
Nervous system	Muscular pain, Back pain, Neuralgia, Spondylosis, Arthritis and Rheumatism
Digestive system	Peptic ulcers
Ear	Hearing loss due to high noise
Others	Radiant heat, High temperature near furnace, CO gas and Asbestosis due to

	asbestos cement products

Prophylaxis (Control measures) are engineering control and medical monitoring.

Engineering control includes methods of elimination or minimisation of dust exposure. Local exhaust (suction hood), cyclone dust collector, unit dust collector, electrostatic precipitators, substitution of wet grinding for dry grinding and hydro-blasting for sand blasting and built-in devices with grinding and polishing machines etc. are generally used. They should be maintained in good working conditions. Workers should wear dust masks/respirators and eye protection also.

Medical monitoring includes appraisal of dust generating places or processes, area monitoring and analysis, medical examinations including X-ray and sputum test, lung function test and clinical tests.

See Chapter-24 also.

10.2 Noise and Vibration :

For figures, pictures and detail see Chapter-12.

Crushers, grinders, compressors and heavy lifting machinery in construction industry cause high noise. Continuously working near such high noise causes hearing loss, deafness, annoyance/change in heart rate, blood pressure, sweat rate, work performance etc. and also psychological and psychomotor effects. High frequencies are more serious than low frequencies. Noise level should be kept below 90 decibels by using quieter machinery and processes, enclosures and silencers. If this is not possible, workers should be given ear plugs or muffs of good quality.

10.3 Heat and Humidity :

For figures, pictures and detail see Chapter-10 and 24.

Steel mills, forge shops, furnaces, boilers, hot asphalt, tar, steam, hot water, damp clay, under-water work etc. expose heat or humidity.

In dry hot atmosphere, thermal balance can be maintained by evaporation of sweat but in moist hot atmosphere as in cotton mills, process of perspiration (sweat evaporation) slows down due to humidity and workers feel great discomfort and their productivity gets down due to heat stress. Main three types of heat stresses are heat stroke, heat exhaustion and heat cramp.

Insulation of hot processes and parts, lagging of hot pipes, shielding against radiant heat, local exhaust ventilation, improvement in general (natural or mechanical) ventilation, spot cooling of hot object, isolation or segregation of hot processes, replacement of workers near furnaces or giving frequent recesses and adequate supply of drinking water are some of the remedial measures.

10.4 Other Hazards :

Use of solvents, thinners, paints, varnishes etc. cause fire hazards. See Chapter-13 for fire safety. Use of chemicals, pigments, radioactive substances and biological agents pose peculiar types of hazards. Their effects and control are explained in Chapter-24. Work permit and special precautions are required when workers have to work at height or in a confined space. See Chapter 16 for details. For electrical hazards and controls see Chapter-11.

10.5 First-aid and Health Services :

For figures, pictures and detail see Chapter-26.

At all work sites, first-aid boxes containing prescribed medicines, antidotes and equipment are most essential. Trained first-aiders should also be employed. They should be proficient in the use of resuscitation and other life-saving techniques and in rescue procedures. Necessary equipment including stretchers should be readily available.

All workers should be subject to health surveillance. Work area monitoring should be carried out. Health services should be available at workplace or nearby. See Chapter-24 for further details.

See Chapter XXIV, Rules 223 to 232 of the BOC Workers Rules, 1998, for medical facilities. It requires medical examination, construction medical officer, OHC, ambulance room, ambulance van, stretchers, FAB, emergency treatment, notice of occupational diseases etc.

10.6 Welfare :

At or near work site, adequate supply of drinking water, sanitary and washing facilities or showers, change or cloak room, lunchroom or canteen, rest room or shelter, facilities for food and drink and suitable living accommodation should be available to workers. The size and number of such facilities may vary according to the number of workers. Where necessary separate facilities should be provided for male and female workers.

See Chapter XXVID, Rules 242 to 247 of the BOC Workers Rules, 1998, for statutory provisions regarding above welfare facilities.

10.7 Accident Reports and Records :

For statistical tables see Chapter-5 and 19.

Where prescribed, as in case of factory premises, all accidents to construction workers should be reported to the authorities where absenteeism due to accident lasts for more than 48 hours. All fatal accidents should also be reported to police and the family of the deceased. Where format is prescribed (e.g. Form 21, GFR), it must be reported in that form only.

Record of non-reportable accidents including near-misses should be maintained for internal use.

All accidents should be thoroughly investigated by a team of concerned officers including Safety Officer and their conclusions should be used as remedial measures to prevent future accidents.

Non-factory construction sites should report their accidents to the authorities prescribed.

A good record of all such accidents and their costs should be maintained for a long time. It may be useful to draft a law or to make internal rules and regulations. See Part 9 of Chapter-5 and Part 3 of Chapter-19.

Safety Committee should be constituted and a Safety Officer should be appointed in every establishment wherein 500 or more construction workers are employed as required by Section 38 of the Building and Other Construction Workers Act, 1996.

See Rule 210, Form XIV for accident report and Rule 230, Form XIII for notice of poisoning or disease, of the BOC Workers Rules, 1998.

10.8 Ergonomics :

For figures and pictures see Part 3 of Chapter-24.
Different postures while doing construction operations, seat and control arrangement in lifting and shifting material, equipment and vehicles, use of hand tools etc. require ergonomic considerations.

In a study conducted by NITIE (National Institute of Training for Industrial Engineering, Bombay), in 1989, on construction workers, 10 different tasks were evaluated for their severity. The tasks of excavation/digging, plastering, climbing with 15 Kg weight, bending reinforcement bars and concreting were found to be severe. The energy expenditure for these activities ranged between 8 to 10 Kcal/min and the heart rate between 130 to 150 bpm. Others like casting, painting, mixing cement and aggregates with water and masonary work were placed in the category of light and moderate work. The energy expenditure in that case ranged between 2.5 to 8 Kcal/ min and heart rate between 90 to 135 bpm.

In plastering, a stooping posture was found to be harmful. It would be better to adopt a squatting posture for plastering the wall area below the hip level.

The workers reported acute pain in elbows of the arm holding the working pan. A simple use of a stool or stand to put the pan can reduce the pain. The use of a longer handle for the patella can be resorted to reduce stooping.

E X E R C I S E

1. State, Explain, Mention or Discuss -
   1. The reasons for health and safety problems and safety measured based on NITIE study (1989).
   2. The main provisions under the Building and other Construction Workers Act 1996 or Rules (1998) there under.
   3. What are the precautions necessary to run- (1) Crusher plants (2) Power generators (3) Engines (4) Transport equipment.
   4. Safety precautions required for –
      (a) Excavation work (b) Drilling, Loading & Blasting (c) Mobile asphalt layers (d) Crushers plants
   5. The safety measures necessary while carrying out tunneling and shaft sinking OR Safety measures for wall and floor openings.
   6. Sequence of demolition OR Precautions during demolition.
   7. At length the health and welfare of construction workers.
   8. The difference in hazards and control measures while doing under ground, above ground or under water works.
2. Write Short Notes on –
   1. Basic philosophy
   2. Dust hazards.
   3. Cofferdam.

4. Shoring & Under pinning.
5. Derricks.
6. Precautions prior to demolition
7. Winches or Hoists.
8. Excavators or Road rollers
9. Concrete mixtures
10. Pneumatic compressors
11. Duties of a Construction Safety Officer or a Construction Medical Officer.
12. Role of a Construction Welfare Officer.
13. Ergonomic aspects in construction work.
14. Siderosis or Anthracosis.
15. Caissons or Cast-in-situ concrete structures
16. Site planning and layout OR Precautions for movement of materials and men.

3. "Fall from height and struck by falling objects, are the two major causes of fatal accidents in construction activity" Justify this statement with statistics or actual case studies.
4. Design a safety work permit at construction site OR A construction safety check-list.
5. Classify the construction machinery and explain in detail any two of them.
6. You are deputed as a construction supervisor for structural steel work and erection. Narrate what precautions you will observe.

Reference and Recommended Reading

1. Safety and Health in Construction, ILO, Geneva.
2. Safety in Construction Industry, NSC, Mumbai – 22.
3. Safety Manual of Essar Projects Ltd. (EPL).
4. Industrial Safety & Pollution Control Handbook, NSC & ADP.
5. The Building and other Construction Workers Act, 1996 and the Central Rules, 1998.
6. The Factories Act, 1948 and the GFR 1963.
7. Indian Standards on Civil Engineering.
8. Safety and Health in Building and Civil Engineering Work – ILO.
9. Construction Safety Auditing Made Easy : A checklist approach to OSHA Compliacne, Second Edition by Kathleen Hess- Kosa.
10. Construction Safety Handbook : A practical guide to OSHA Compliance and Injury Prevention, Second Edition by Mark McGuire Moran.
11. Excavation Safety, A guide to OSHA Compliance and Injury Prevention by Carl O. Morgan.
12. Handbook of OSHA Construction Safety and Health, 2nd Edition.
13. Building Construction by Jha and Sinha, Khanna Publishers, Delhi.
14. Safety in Construction work – Excavations – by HMSO, London.
15. Construction site safety by Hishop.
16. Construction safety and Loss Control by Citelow.

CHAPTER – 23

Safety in Construction Industry

THEME

1. INDUSTRIES NEEDING ATTENTION

Three questions are important from safety point of view:

1. Which industries are more in number?
2. Which industries employ more men-power?
3. Which industries have more accidents?

According to the number of working factories (as per Table 5.16 in Chapter-5) the chronological order is as follows:

1. Chemical and Chemical Products.
2. Non-metallic Mineral Products.
3. Machinery and Parts.
4. Wool, Silk and MMF.
5. Food Products.
6. Metal Products and Parts.
7. Basic Metal and Alloy Industry.
8. Cotton Textiles.
9. Rubber, Plastic and Petroleum.
10. Wood and Wood Products.
11. Paper and Paper Products.
12. Electrical Machinery and Parts.
13. Other Manufacturing.

14. Transport equipment parts.
15. Textile Products.
16. Repair services.
17. Beverages, Tobacco.
18. Repair of Capital Goods.
19. Education, Science & Research Services.

According to the number of workers employed, (as per Table 5.16 in Chapter-5) the chronological order is as under :

1. Chemicals and Chemical Products.
2. Cotton textiles.
3. Wool, Silk and MMF.
4. Food Products.
5. Non-metallic Mineral Products.
6. Machinery and Parts.
7. Rubber, Plastic and Petroleum.
8. Basic Metal and Alloy industry.
9. Metal Products and Parts.
10. Electrical Machinery and Parts.
11. Paper and Paper Products.
12. Transport equipment & parts.
13. Other Manufacturing.
14. Repair services.
15. Textile Products.
16. Electricity, generation, transmission & distribution.
17. Wood and Wood Products.
18. Beverages, Tobacco.
19. Education, Science & Research Services.
20. Repair of Capital Goods.
21. Water Works & Supply.

According to the number of accidents, (Table 5.22 in Chapter-5) the order is :

1. Cotton textiles.
2. Machinery and Parts.
3. Chemicals and Chemical Products.
4. Wool, Silk and MMF.
5. Basic Metal and Alloy industry.
6. Non-metallic Mineral Products.
7. Rubber, Plastic and Petroleum.
8. Repair of Capital Goods.
9. Metal Products & Parts.
10. Repair Services.
11. Food Products.
12. Other Manufacturing Industries.
13. Paper and Paper Products.
14. Transport Equipment &: Parts.
15. Jute & other Vegetable Fibre Textile.
16. Wood and Wood Products.
17. Beverages, Tobacco.
18. Textile Products.

An all India order (as per Table 5.9 in Chapter5, for the year 1990) according to the number of injuries (frequency rate) is as follows :

1. Jute & Vegetable Fibre Textiles.
2. Cotton Textiles.
3. Non-conventional Energy Generation.
4. Other Manufacturing Industries.
5. Rubber, Plastic & Petroleum.
6. Gas & Steam Generation & Distribution.
7. Transport Equipment.
8. Basic Metal Industries.
9. Non-metallic Mineral Products.
10. Wool, Silk & MMF.
11. Electricity, generation, transmission & distribution.
12. Food Products.
13. Paper and Paper Products.
14. Repair of Capital Goods.
15. Chemicals & Chemical Products.
16. Wood and Wood Products.
17. Textile Products.
18. Metal Products & Parts.
19. Beverages, Tobacco.
20. Machinery.
21. Leather & Leather Products.
22. Water Works & Supply.

According to the number of accidents in Gujarat and India, textile industry has the highest number of accidents and injuries. But this trend is changeble.

In Gujarat, numberwise and workerswise chemical industry is at the top.

Out of above industries, we have studied so far up to the last chapter, the cotton textiles, chemicals, synthetic fibres, machinery, metal products, basic metals and alloy industries and electrical machinery industries. Therefore the statutory provisions and the safety aspects with inspection experience of the remaining main industries are given below in brief.

2 ASBESTOS MANUFACTURE AND HANDLING

Asbestos-chrysotile, crocidolite or amosite in natural fibrous silicate forms - is a white, blue or grey brown substance (available from 1880). It is a cheaper man-made mineral fibre used for many products. Its main uses are in asbestos-cement products as roofing sheets, pipes and wall boards.

Asbestos dust causes lung damage. Fibrosis of the lung by asbestos was first described with PM report by Montague Murray in 1899. The name asbestosis was given by Cooke in 1927.

Control of airborne contamination becomes difficult and costly. Therefore effective enclosures to source of generation and local exhaust ventilation on machine, wetting of fibres before mixing, spinning and weaving, vacuum cleaning instead of brushes and changing of clothing at the end of work are the best controls. Dust masks are also essential.

Asbestos dust is a confirmed human carcinogen and its STEL/CEILJNG values published by ACGIH are as under :

Crocidolite	-	0.2 fibre/cc
Amosite	-	0.5 fibre/cc
Chrysolite and other forms	-	2.0 fibre/cc

The 2^{nd} Sch. of the Factories Act gives this value as 2 fibres/ml (length 5 nm and breadth 3)Lim as respirable dust).

Asbestosis is an occupational disease specified in the 3rd Schedule of the Factories Act. See Part 4 of Chapter-24 for further details.

Statutory Provisions:

Summary of Schedule 17, rule 102, GFR i.e. Gujarat Factories Rules, Sch.17 u/r 114, MFR i.e. Maharashtra Factories Rules and Sch.20 u/r 95 of the TNFR i.e. Tamil Nadu Factories Rules is as under :

Application :

This schedule is applicable to the process of asbestos in any form of making insulation slab or mattresses, textile, cardboard, paper, cement goods consisting asbestos or spraying asbestos or cleaning asbestos dust. Definitions:

Asbestos is a fibrous silicate mineral and any admixture of silica known by different names. Its dust means airborne particles. Respirable asbestos fibres means those having diameter less than 3 µm and a length to diameter ratio greater than 3:1. Other terms are also defined.

Tools and Equipment:

They should not create asbestos dust above the permissible limit or they should be equipped with efficient exhaust draught.

Prohibition :

Processes of tools releasing asbestos dust beyond the permissible limit, use of crocidolite, spraying of asbestos and installation of friable asbestos insulation materials are prohibited.

Employment of young persons and smoking are also prohibited.

Substitution :

Asbestos shall be used only when its risk can be prevented or controlled, otherwise it shall be replaced by other less harmful or harmless material or technology.

Restriction :

Number of persons exposed to asbestos and their exposure time shall be kept minimum. Their work area shall be 'demarcated by warning signs restricting unauthorised access.

Exhaust draught:

An efficient exhaust draught shall be provided and maintained to control dust from the process and machines prescribed in para-4 (1) of the Schedule. Dust coming from the exhaust apparatus shall be collected by filter bags or suitable receptacles and shall not be drawn free into the air of any work room.

Testing of Ventilation System :

A responsible person shall inspect the system every week. A competent person shall test it every year. Defects found shall be rectified forthwith. Test report shall be in form No. 26-A.

Segregation :

Dust creating work places shall be segregated from other work places to avoid exposure to other workers.

Breathing Apparatus & Protective Clothing :

An approved type of breathing apparatus and protective clothing shall be given to workers, for working in chamber or cleaning dust or filling , beating or other operation where it is not possible to keep the dust within permissible limit. Separate accommodation shall be provided to put on or take off such apparatus and clothing and to store when not in use.

All protective clothing shall be deducted under an efficient exhaust draught or by vacuum cleaning and shall be washed at suitable intervals. The cleaning schedule and procedure shall be established to ensure the efficiency of protection.

They shall be cleaned and disinfected at suitable intervals and inspected every month by a responsible person.

A record of cleaning and maintenance shall be maintained. Full instruction shall be given to the user before employing in such work. No apparatus worn by a person shall be worn by another person unless it has been thoroughly cleaned, disinfected and full instruction given to that person.

Separate accommodation other than that for breathing apparatus, shall be provided to store other personal protective equipment or personal clothing.

Washing and Bathing Facilities :

Washing places shall be provided at the rate of I for 15 persons. Stand pipe separation shall be more than a metre. Constant water, clean towels, soap, and nail brushes shall be provided. Washing (bathing time of 30 minutes within working hours) shall be provided at the end of the shift.

Mess Room :

A suitable mess room with tables, benches (with back rest) and means to warm food shall be placed under the charge of a responsible person and be kept clean.

Cautionary Notice :

Cautionary notices regarding (i) Health hazards from asbestos dust (ii) Need to use appropriate equipment and (iii) Entry of authorised persons with protective equipment or no entry shall be displayed.

Labelling:

The container of asbestos or its products shall be labelled with warning of dust hazard and its safety measures. MSDS shall be supplied to consumers.

Information regarding health hazards of home carrying contaminated clothing shall be given to the families of the workers.

Air Monitoring :

Monitoring of asbestos fibre in air shall be carried out once in every shift. Time weighted average concentration shall be calculated or measured by Membrane Filter Technique (MFT). Records shall be preserved for thirty years.

Medical Tests and Records :

1. A doctor shall be employed with the approval of the CIF*. Medical facilities shall be provided to him.
2. The CS** will examine a new worker within 15 days of his first employment. This will include pulmonary function tests, tests to detect asbestos fibres in sputum and chest X-ravs. No worker shall be employed without: Fitness Certificate in Form No. 27 A by the CS.
3. Periodical tests every year by the CS.
4. Health Register in Form No. 20 to be signed by the CS. Reasons of unfitness shall be recorded in it. Re-employment in the same process is possible with a Fitness Certificate from the CS.
5. Post Medical Examination shall also be carried out. No cost to the workers. Results shall not be used to discriminate against the worker. Workers will be informed about the test results. If health is impaired due to long time exposure, the worker shall be compensated to maintain his income.
6. Records of Medical Examinations shall be preserved for 30 years. On closure of the factory, the records shall be deposited to the Office of the GIF.

* CIF = Chief Inspector of Factories
** CS == Certifying Surgeon

Other Provisions :

1. Loose asbestos, while not in use, shall be kept in closed receptacles.
2. A sack containing asbestos shall not be cleaned by hand beating but by a safe machine.
3. Disposal of waste should not pose health hazard to workers or the public in the vicinity.
4. All floors, work benches, machinery and plant shall be kept clean and free from asbestos dust. Vacuum cleaning equipment shall be used, otherwise respirators will be given to the cleaners. The cleaning apparatus shall also be cleaned for asbestos waste and dust.

IS : Safety and health requirements relating to exposure to asbestos 11451, Asbestos dust control 11770, cleaning premises 11767, airborne concentration 11450, chrysotile 9690, 11276, 11267, Manufacturing premises - exhaust ventilation system 12080, packaging, transport & storage 12079, personal protection of workers 12078, products safe use 11769, terminology 11707, workplace pictorial warning 12081, products 5913, control recommendation 12082, corrugated sheets 459, 13008, asbestos fibre 2712, 11275, 9745, yarn 13362.

3 AUTOMOBILE INDUSTRY

This is a part of an engineering industry and carries out various processes like casting, forging, machining, electroplating, painting, assembly, testing etc. The safety measures include :

1. Noise and vibration control.
2. Dust, fumes and gas emission control by
3. High temperature control near furnaces by insulating material or heat reflective surfaces to heat source.
4. Heat protective clothing, eye and face protection.
5. Mechanical lifting.
6. Guarding of drilling, reaming, grinding, milling machines, power presses, conveyor belt etc.
7. Machine tools with splash guards.
8. Barrier creams and oil-resistant aprons. .
9. Welding and soldering precautions.
10. Electroplating baths with special lip ventilation and anti foaming surface tension agents.
11. Solvent and spray controls with special booths in painting shop Paint dipping and electrostatic or electrophoretic painting requiring worker outside are more safe.
12. Dryers with exhaust ventilation.
13. Controls for chemicals which are toxic, flammable and explosive.
14. Electrical safety.
15. Precautions against silicosis, solvent poisoning, lead poisoning, skin diseases. X-rays for nondestructive testing etc.

See Table 15 of Chapter-32 for TLVs of Silica and other chemicles.

IS : Safety Code for industrial trucks 6305 (Part I & 2), life jackets 6685, protective helmets 4151, stability testing of forklift trucks 4357, 5752, 5753, conveyor safety 7155 (Part I to 7), glossary of terms 7862, smoke emission for diesel vehicles 8118, CO emission limits 9057, braking system 11852 (Part I to 7), driver safety 11939, life saving equipment 10548, speed limiters 10144, automobile accessories 8925, 8098, control cables 5836, electric equipment 9175, light-reversing 9961, stop, tail & turn signal lights 10256, wiring cable terminations 8395, Automotive vehicles - accelerator control, safety requirements 14283, air brake system 11852, 12831, 12821, electronic flashers 13135, pneumatic tyres 10914, rear view mirrors 14210, registration plate 14224, side doors safety requirements 12009, terms & definitions 13111, windows for buses, safety requirement 13944.

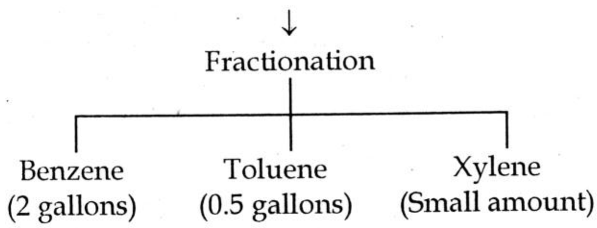
4 BENZENE MANUFACTURE, HANDLING AND USE

Manufacture :

Benzene is a solvent frequently used in many organic processes. It is also used as a fuel, additive of motor fuel, chemical reagent and a raw material for large number of chemical synthesis.

Old process of obtaining benzene is from coal. Its line diagram is as under :

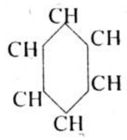
Coal (1 ton) → Coke (1500 lb) + Light oil (3 gallons] + Coal tar (8 gallons) + Ammonium sulphate (20 1b) + Illuminating gas (11200 cuft)



Benzene and related compounds (toluene, xylene) are also obtained commercially by subjecting open-chain alkanes obtained from petroleum to cyclization followed by dehydrogenation. This conversation is brought about at high temperatures and pressures in the presence of suitable catalysts :

n-Hexane → catalyst → Benzene
n-Heptane → catalyst → Toluene

Benzene can also be produced by cyclization and aromatisation of paraffin hydrocarbons. Benzene is the simplest member of the aromatic group of compounds. It is represented by a closed ring of six carbon atoms as –



i.e. C_6H_6.

Hazards and Control:

Benzene is lighter than water (sp'. gr. 0.88) and heavier than air (vd 2.8). Its other properties are BP 80.1 °C, FP -II °C, explosive range 1.3-7.1 %. It is less soluble in water, but highly soluble in organic solvents and oils.

Looking to its very hazardous nature, the ILO passed its Benzene Convention 1971 (No. 136) and Recommendation 1971 (No. 144).

It is highly flammable, explosive and toxic, all at a time. It exerts acute as well as chronic poisoning. Its TLV is 10 ppm (30 mg/m^3), STEL 25 ppm (75 mg/m^3) and IDLH 2000 ppm. ACGIH booklet 2007 shows TLV (TWA) as 0.5 ppm and STEL as 2.5 ppm.

Fatal cases of blood disease - leukaemia - have been reported. It destructs bone marrow. Benzene handling must be in a closed system. Its exposure must be measured in work areas and the affected person (by medical examination) must be immediately removed from exposure. Less hazardous substitutes like toluene, xylene, cyclohexane and other suitable solvents e.g. alcohol, ketones, esters etc. should be used. Good ventilation including exhaust ventilation, plant enclosures, flameproof fittings, leak detector with alarm, environmental and biological monitoring (estimation of urinary phenols), breath sampling, dyke surrounding storage tanks, curbs round the process vessels, elimination of sparks, flames and excessive heat and effective fire fighting arrangement are necessary.

Statutory Provisions:

Schedule-20 u/r 102, GFR, and also as Schedule20 u/r 114 of the Maharashtra Factories Rules, 1963, (MFR) and as Schedule-27 u/r 95 of the Tamil Nadu Factories Rules, 1950 (TNFR) gives safety provisions regarding manufacture and use of Benzene or substances containing benzene.

This Schedule is applicable to manufacture, use, storage, packing or handling of Benzene or substances containing benzene (means wherein benzene content exceeds 1% by volume).

Manner of using Benzene or its substitute (less harmful) includes enclosed system or equally safe system.

Protection against inhalation prescribes enclosed system or efficient exhaust draft to remove benzene vapours from the workroom so that its concentration in air does not exceed 25 ppm or 80 mg/ 3 Its measurement and report of concentration exceeding above limit to the Inspector are compulsory. The workers exposed to such higher exposure shall be given necessary respirators.

To avoid skin contact suitable gloves, aprons, boots and vapour tight chemical goggles (not affected by benzene) should be given to workers.

Other provisions include prohibition of employment of women and young persons, labelling of name, danger symbol, toxicity and flammability, no misuse of benzene for hand cleaning etc., no food, drink, smoking or chewing in the workroom, instruction regarding risks, cautionary notice (as per Appendix-B), washing facilities, cloak room and mess room, medical examination, pre-employment and six monthly medical examination including blood test and other biological tests and temporary shifting of the exposed worker.

Appendix-A specifies the processes where benzene substitute is not possible i.e. its production, chemical synthesis and motor spirit (use of fuel).

Appendix-B is a cautionary notice specifying the hazards, preventive measures, protective equipment and first aid measures in case of acute poisoning. It is reproduced below :

APPENDIX B

(A) The hazards :

1. Benzene and substances containing benzene are harmful.
2. Prolonged or repeated breathing of benzene vapours may result in acute or chronic poisoning.
3. Benzene can also be absorbed through skin which may cause skin and other diseases.

(B) The preventive measures to be taken :

1. Avoid breathing of benzene vapours.
2. Avoid prolonged or repeated contact of benzene with the skin.
3. Remove benzene soaked or wet clothing promptly.
4. If any time you are exposed to high concentration of benzene vapours and exhibit the sign and symptoms such as dizziness, difficulty in breathing, excessive excitation and losing of consciousness, immediately inform your - Factory Manager.
5. Keep all the containers of benzene closed.
6. Handle, use and process benzene and substances containing benzene carefully in order to prevent their spillage on floor.
7. Maintain good house-keeping.

(C) The protective equipment to be used :

1. Use respiratory protective equipment in places where benzene vapours are present in high concentration.
2. In emergency use self-generating oxygen mask or oxygen or air cylinder masks.
3. Wear hand gloves, aprons, goggles and gum-boots to avoid contact of benzene with your skin and body parts.

(D) The first aid measures to be taken in case of acute benzene poisoning:

1. Remove the clothing immediately if it is wetted with benzene.
2. If liquid benzene enters eyes, flush thoroughly for at least 15 minutes, with clean running water and immediately secure medical attention.
3. In case of unusual exposure to benzene vapour call a physician immediately. Until he arrives, do the following :

If the exposed person is conscious -

1. Move him to fresh air in open.
2. Lay down without a pillow and keep him quiet and warm.

If the exposed person is unconscious -

1. Lay him down preferably on the left side with the head low.
2. Remove any false teeth, chewing gum, tobacco or other foreign objects which may be in his mouth.
3. Provide him artificial respiration in case difficulty is being experienced in breathing.
4. In case of shallow breathing or cyanosis (bluish skin, lips, ear, finger, nail, beds), he should be provided with medical oxygen or oxygen carbon dioxide mixture. If needed he should be given artificial respiration.

IS : Benzene 534, safety code 4644, reagent grade 1840, insoluble matter determination 1214.

5 BEVERAGE INDUSTRY

Use of soft drinks (non-alcoholic carbonated and non carbonated or still drinks) is increasing day by day. Industrial safety measures include :

1. Guarding of high speed bottling and canning machines.
2. Net or wire mesh screening under over head conveyors.
3. Nip guards on conveyor belts, drums and pulleys and frequent stop buttons for conveyors.
4. Ammonia respirators and water type fire extinguishers or sprinklers.
5. Bottling machines with strong shields to contain bursting bottles or siphons.
6. PPE to workers for protection against broken glass.
7. Containers for broken glass equipped with a hinged clover or long chute to prevent "fly back".
8. Mechanical handling.
9. Dry floors by proper draining and cleaning. Workers with safety shoes with tread type soles. Tennis shoes and sandals not permitted. Waterproof aprons.
10. Fixed platforms (instead of portable ladders), catwalks and stair ways with open grating to mixing tanks and elevated locations.
11. PPE and water showers for caustic splashes.
12. Waterproof and properly earthed electric fittings.
13. Noise control by reducing the number of impacts, speed of bottle travel, acoustic barriers, enclosures and ear protection.

14. First-aid including waterproof plasters and dressings.

See also schedule I, Rule 102, GFR and also Sch.l u/r 114, MFR and Sch.l u/r 95 TNFR.

IS : Beverages (Aerated water)- protein based 7482, protein food 9038, carbonated 2346, nonalcoholic 13019, sensory evaluation 8140, 8639.

6 BRICK AND TILE INDUSTRY

Bricks and tiles are essential building materials. Their clay work should include :

1. Chute feeds as protection against falls.
2. Guarding of presses, dies, tools, pug-mill gears and drives, rollers, edge runner pans.
3. Oiling, greasing and repairs only when the machinery is at rest.
4. Good lighting, flooring and electric fittings.
5. Dust producing equipment viz., crushers, vibrators, conveyor belts with' local exhaust ventilation.
6. Moistening of raw materials and premises to suppress flying dust.
7. If sand is applied, it should be made wet by mechanical means and local exhaust ventilation with compressed air.
8. Glazes should be non-lead type. Lead is hazardous.
9. Correct draft conditions in kilns to prevent carbon monoxide.
10. PPE and clock room.
11. Mechanical handling.

Refractories (Substances with high melting point and good physical resistance) are of four types: alumina-silicate, silica (or acid), basic and miscellaneous. Hazard control is as stated above. Here chances of silicosis are more. Permissible concentration of fibrogenic dust should not be exceeded. Manual breaking should be avoided. Mechanical crusher/ grinder with exhaust draft and dust collectors or water or steam spray are essential. Floors should be cleaned by vacuum cleaning.

See Sch. 5 for grinding or glazing of metals and Sch. 18 for stone or other material containing free silica, under Rule 102, GFR.

IS : Brickwork - measurement 1200, code of practice 2212, Brick-acid resistant 4860, alumina 8953, 14313, building heavy duty 2180, work with compressed air 4138, piling and deep foundations 5121, handling of building materials 7969, Falling hazards 13416 (Part I & 2), scaffolds and ladders 3696 (Part I & 2), Tiles cement concrete 10646, brick flooring laying 5766, insulating 2042, kiln, design and construction 4805, paving 3583, sand lime 4139, silica mortar 1292, brick panel 14143.

7 CANNING AND FOOD INDUSTRY

There are six methods of food preservation heating, radiation sterilisation, antibiotic sterilisation, chemical action, dehydration and refrigeration (frozen food industry). Industrial safety measures include :

1. Training for safe lifting, stacking and maintenance of good housekeeping. Mechanical handling avoid manual hazards.
2. Machines designed for less spillage.
3. Floors clean, dry and drained.
4. Protection against burns due to hot liquors,
5. Guarding of filling and closing machines, conveyor belts and drums, pulleys and gears.

6. Safety valves and pressure controls where steam is used.
7. Vaccination against infectious diseases, good personal hygiene, sanitary and washing facilities.
8. For noise control sound absorbent mounting, magnetic elevators, nylon coated cables and speed matching in can conveyor systems, use of plastic containers and ear protection.
9. Ventilation systems with special attention to condensation problems.
10. At ionising radiation, full protection, hazard monitoring, health screening and medical examinations are necessary.
11. Control of lead levels due to side seam soldering. Avoidance of lead content.

IS : Canning fruit and vegetable hygienic code 6542, Food analysis handbook SP-18, bacterial detection 5887, 7688, sampling and tests 1699, freezers, safety 10542, processing units 2491, 8077, cereals, warning 1656, 1657, safe use of packing 7277, 7288, 7961, food colours 5346, test for dye content 6120, food mixers, electric 4250, food container, metal 6093, hawker, hygienic conditions 10973, plastic for packaging 10171, food poisoning bacteria 7688, food samples analysis 5404, food yeast 3839, food service establishments 6074, 7021, 8220.

See Part 18 also.

8 CS_2 and H_2S PLANT

Carbon di or bisulphide, CS_2 is found in coal tar and crude petroleum. It is produced by heating charcoal with vaporised sulphur or by reacting sulphur with petroleum hydrocarbons. Reaction is $C + S_2 = CS_2$ Pure product is obtained by distillation of crude CS_2 and it is kept submerged in water.

It is a colourless, odourless gas with following .properties:

Sp. gr.	1.26	ER	1.3-50%
VD	2.6	IT	100 ^{0}C
BP	46.3 ^{0}C	TLV,NIOSH	1 ppm
FP	-30 ^{0}C	TLV (skin)	10 ppm
			30 mg / m^3

IDLH 500 ppm (under the Factories Act & ACGIH)

Acute and chronic poisoning occurs in viscose rayon industry. CS, poisoning is a notifiable disease in the 3rd Schedule of the Factories Act. It has toxic and fire hazard. It is a neurotoxin. Therefore effect on CNS is the main symptom. It affects liver and kidneys also. Chronic poisoning begins with headaches, fatigue, weakness and sleep disorder.

Safety measures require total enclosed system, general and local ventilation, exposure measurement, iodine-azide test of urine (biological measurement), pre and periodic medical examinations.

Statutory Provisions:

Summary of Sch. 14 u/r 102, GFR, Sch.l4 u/r 114 MFR and Sch. 30 u/r 95 TNFR for CS_2 and H_2S is as under :

Amongst other definitions, 'efficient exhaust draught' is defined as localised ventilation effected by mechanical means for the removal of gas or vapour, so as to prevent it, as far as practicable from escaping into air of any occupied room. No draught shall be deemed to be efficient if it fails to remove smoke generated at the point where such gas or vapour originates.

Other provisions include

1 Prohibition of employment of women & young persons.
2 Efficient exhaust draught on CS_2 churn to keep CS_2 exposure below 20 ppm, and also on H_2S fumes. SBA necessary if ventilation is ineffective or stops suddenly, otherwise the worker shall leave the room as soon as possible or within 15 minutes of such occurrence. Fresh air inlets shall also be provided.
3 Air analysis to measure CS_2 and H_2S every 8 hours and its record. Exposure of CS_2 or H_2S above 20 ppm, its duration and reason shall be reported to the CIF. Manager's duty to reduce the excess exposure.
4 Electric fittings in CS_2 fume process room shall be flameproof.
5 Washing facilities - 1 tap per 5 workers, standpipe within 1.2 mt spacing and sufficient supply of soap and clean towels. 6 PPE as specified in the Table. Its use compulsory. Suitable storage room or lockers necessary.
7 Mess room of at least 1 mt^2 per worker, in charge of a responsible person and furnished with tables, chairs, wash-basin and means to warm food.
8 Prohibition of smoking and source of ignition. Notice necessary.
9 Medical examination of workers employed in a fume process, by the CS (Certifying Surgeon) every year. Record in Health Register.
10 Medical practitioner (MBBS with PG Diploma in Industrial Health or 5 years experience) and his duties.
11 Breathing apparatus & life belts.
12 Cautionary placard and instructions.

Looking' to the prescribed TLV 10 ppm for both CS_2 and H_2S, under the Second Schedule of the Factories Act, that limit of 20 ppm stated in the State Rules should be changed to 10 ppm on safer side and to bring uniformity in the provisions of the Act and Rules.

Summary of Schedule 22, rule 102, GFR, Sch.19 u/r 114, MFR and Sch.26 u/r 95, TNFR is as under

(1) Application:

This schedule is applicable to CS,„ manufacturing plant containing electric furnace, condenser, refiner and storage.

(2) Construction and operation :

Building should have optimum ventilation. Workers at risk of fire/explosion should be minimum. Furnace should be sound with supports grounded 60 cms in concrete. Operating instructions to be strictly followed.

(3) Electrodes:

Seamless tubes with cooling water system giving alarm of interruption of water in the electrodes and stopping power supply for furnace operation. Electrodes should be kept covered with charcoal bed. Charcoal separator required between the furnace and sulphur separator to prevent charcoal entry into condensers and piping.

(4) Rupture Disc and Safety Seal :

Two rupture discs on each furnace to blow off at. twice the maximum operating pressure. Water sealing arrangement between charcoal separator and sulphur separator.

(5) Pyrometers and Manometers :

Pyrometers on furnace with dials in control room to know temperature of the furnace and manometers to know pressure (1) before and after the sulphur separator and (ii) in primary and secondary condensers.

(6) Check valves:

They are required on CS carrying piping to prevent back flow of gas in to the furnace in the event of its shut down.

(7) Bulk Sulphur Storage :'

Sulphur dust being explosive, its clouds generation should be minimised and its contact with spark, flame etc. should be prevented. Use non-sparking tools. Smoking, matches and sources of ignition not allowed.

(8) Other provisions:

1. Inspection and maintenance by a competent person and in a prescribed manner.
2. Hourly record and log book for gas and water temperature, pressure, primary and secondary voltages and current and energy consumed.
3. Fire/explosion proof electric apparatus, wiring and fittings.
4. Adequate means of escape.
5. Fire warning by electric and non-electric alarm.
6. Adequate number of fire extinguishers.
7. Trained workers and supervisors.
8. Washing facilities with one tap per five workers, pipe spacing more than 120 cms and soap, towel etc.
9. Suitable PPE to workers.
10. Cloakrooms to put work clothing and personal clothing. In-charge person should be appointed.
11. Unauthorised, persons shall not be admitted in the plant.

IS : Code of safety for Carbon disulphide 5685, technical 717.

9 CARCINOGENIC DYE-INTER MEDIATES

Dye or dyestuff are soluble colours and the textile fibre or other materials are immersed in their solution for dyeing process. Pigments are insoluble and are applied externally on surfaces by dispersion methods.

Finished dyes are not much hazardous but in making them many intermediates are manufactured from hazardous chemicals like aniline, benzene, naphthalene, anthracene, acids and alkalis etc. and a wide range of dye-intermediates are manufactured (e.g. quinones, aromatic amines etc.) and these intermediates are hazardous and some of them are carcinogenic also.

Auramine and magenta have caused bladder cancer to the workers. Azo dyes derived from benzidine or other chemicals, benzyl violet 4B, 4 amino or nitro diphenyland beta-naphthylamine have carcinogenic potential.

Dermatitis is possible due to skin contact. Respiratory disorders have also been reported.

Statutory Provisions:

Summary of Schedule II, Rule 102, GFR, Sch.22 u/r 114, MFR and Sch.22 u/r 95, TNFR is given below.

Applicability:

This schedule applies to factories where following substances are formed, manufactured, handled or used –

Prohibited substances	Controlled substances
Beta – naphthylamine and its salts	Alpha naphthylamine or Alpha – naphthylamine containing less than 1% of beta-naphthylamine.
Benazidine and its salts	Ortho-toludine and its salts.
4 amino diphenyl and its salts	Dianisidine and its salts
4 nitro diphenyl and its salts	Dichloro Benzidien and its salts
Any substance containing above compounds	Auramine and Magenta

No person shall be employed in process of 'prohibited substances' mentioned above except as exempted by the CIF in writing. This becomes possible if the process is carried out in a totally enclosed, safe and hermetically sealed system as prescribed in para23 of the schedule. The CIF may impose conditions, if any.

Precautions for processes of 'Controlled substances':

1. Prevention of inhalation, ingestion or absorption of such substances.
2. Process in a totally enclosed system or under local exhaust ventilation.
3. Containers shall be tightly closed and properly labelled.

Other precautions:

1. PPE : Long trousers and shirts or overalls with full sleeves and head coverings, rubber gum boots, rubber hand gloves, rubber aprons and respirator if required.

2. Prohibition: No women or young person shall be employed in such process. No person below the age of 40 shall be employed in such process.

3. Floor: Smooth, impervious, no use of tar or asphalt, suitable slope, gutters and daily washing.

4. Empty containers: shall be thoroughly cleaned and inactivated before disposal.

5. No manual handling: Scoop with a handle shall be used. It shall be thoroughly cleaned daily. 6. Instruction & Notice: All workers shall be instructed on properties of toxic chemicals and their safe use including emergency procedure. Prescribed cautionary placards shall be displayed at prominent places.

7. Washing/ Bathing facilities:
   1. Wash places (basin) with clean towel, soap and nail brush to each worker, nearer to work place.
   2. Bathrooms with facility of hot and cold water.
   3. One stand pipe on each floor.
   4. Daily facility to wash uniforms.

8. Food, Drinks etc. - Food, drinks, pan-supari, tobacco and smoking in. workroom are prohibited.

9. Clock room: Lockers with separate compartments for street clothes and work clothes. Separate place from locker room and mess room to store PPE given to the workers:

10. Mess room - With tables, benches and means to warm food.

11. Washing time - 30 minutes for bathing before the end of each shift and 10 minutes for washing before each meal.

12. Medical Examination and Record
   1. Employment of a doctor with approval of the GIF.
   2. Provision of all medical facilities to him.
   3. Examination by the CS within 15 days of first employment. It includes haematological test, paranitrophenol in urine test, pulmonary function test and CNS test. Employment after such fitness certificate (by the CS) only.
   4. 6 monthly re-examination by the CS.
   5. Fitness certificate in Form No. 33 and record in Health Register in Form No. 20. Ready to be shown to the Inspector.
   6. Unfit worker shall be given alternate placement. He can be re-employed in the same process if declared fit by the CS.

IS : Carcinogenic substances, handling safety 14165, Dye application classes 4472, intermediates sampling & tests 5299, pigment for paints 59, dyesbasic strength 12387, dye-hair, liquid 8481, disperse dyes 11635, vat dyes 4394, 5970.

10 CEMENT INDUSTRY

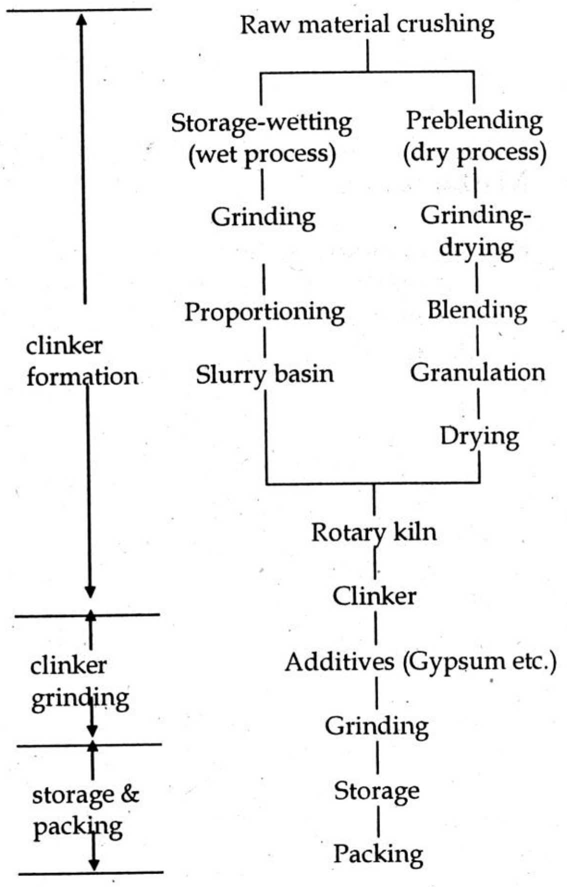
Manufacture :

Cement is mainly made from limestone, clay and small amounts of other metallic oxides, which, when mixed with a small amount of water, sets to a hard stone-like substance in a few hours. It is a main building material working as a hydraulic bonding agent.

Types of cement are portland, pozzolana, calcium aluminate and special or corrosion-resistant cement. Grades are more than fifty.

Cement is a mixture of four essential raw materials i.e. 'calcium, silicon, aluminium andiron. Calcium is obtained from limestone or cement rock or hydraulic calcium silicate i.e. clinker or chalk. Silicon, aluminium and iron can be obtained together from clay or shale or slate or separately from sand, bauxite on and iron ore respectively. Gypsum, fly ash and bias furnace slag are also added in certain proportions Composition of these materials should be proper otherwise the property or quality may change.

Manufacturing process is wet process (old one) dry process (new) or the combined process. The raw materials are finely ground, mixed and heated (burned) in a rotary kiln to form cement clinker During calcining, clinker compounds are also obtained. Various reactions such as evaporation of water, evolution of CO and reaction between lime and clay take place during burning. Liquid formation begins at 1250 °C and fusion occurs near the end of the process. Closed circuit grinding is preferred to open circuit grinding. Process flow chart of the combined process is shown below.



I Storage-wetting (wet process)

Hazards and Controls :

In quarries where limestone, clay, gypsum etc. are extracted, hazards of dusts during drilling and crushing, fall of rock and earth, blasting and bad weather conditions are obvious.

In cement processing area dust levels were found from 41 to 384 mg/m", the highest being at sieving, cement packing and clinker grinding. Modern plants using wet process have 15-20 mg/nr" level. Free silica content in dust is also possible. Electrostatic filters are useful to reduce the air pollution.

High temperature near furnace doors, high noise (upto 120 dB) near ball mills, CO near limestone kiln and dusting at most of the places including conveyor and manual handling cause health hazards. Pathological disorders are found in respiratory, digestive and nervous system, and also in skin, hearing, vision and rheumatic disorders.

Cement Pneumoconiosis may appear after prolonged exposure. Silicosis may not occur in cement plant (because of. absence of free silica) but may occur in refractory processes due to dust containing free silica.

TLV (ACGIH) for Calcium oxide is 2 mg/ m^3 and Aluminium oxide 10 mg/ " USSR-MAC values are as under-:

Cement dust without free silica	6 mg/ m^3
Cement dust with free silica <10%	5 mg/ m^3
Asbestos cement dust with asbestos >10%	5 mg/m^3

2[nd] Schedule of the Factories Act prescribes 10 mg/nr" total dust containing less than 1% quartz as permissible TWA concentration/8 hours TLV for Portland cement.

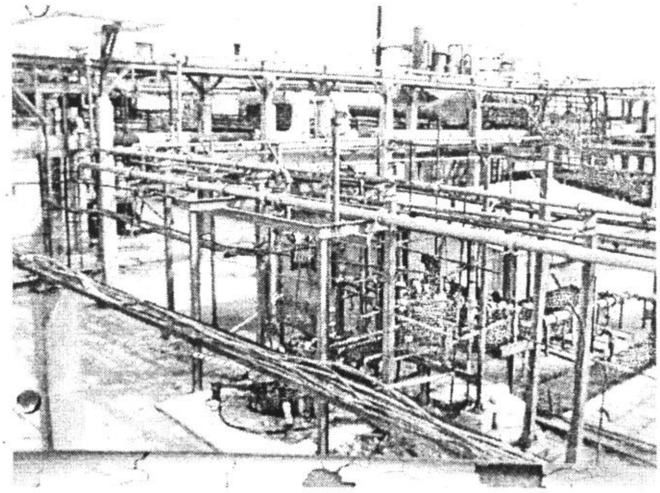
Similarly, the same Schedule prescribes 2 mg/ m^3 respirable dust fraction containing less than 5% quartz as TLV for coal dust.

Cabins of excavators in quarries should be fully closed and the drivers should be supplied fresh air through respirators. Modern surface mining machines do many operations safely. They dig the surface, collect extracted material in ,a trailer, resurface the dug land and utilise wet process and dust suppression system. Dust suppression measures near drilling, crushing and blasting, keeping away (at a distance) from CO possibility at blasting points (fumes), enclosures to dusty processes and to conveyor belts including their drives and transfer points, electrostatic and bag filters at clinker kiln stacks, sieving and packing processes, cold air flow (showers) at hot places, thermal screening, shower baths and barrier creams for skin protection and desensitisation treatment in case of eczema are all important safety measures.

IS : Cement, hydraulic - glossary 4845, sampling 3535, physical tests 4031, flow table 5512, chemical analysis 4032, colorimetric analysis 12423, bag, jute cloth 12001, jute bag for packing 2580, polypropylene 11653, high alumina for structural use 6452, masonary 3466, mastic 3709, test for permeability 3085, oil-well 8229, paint 5410, pipeasbestos 9633, 9627, plants-emission limits for particulate matter 10693, control of air pollution 12002, plaster finishes 1661, Portland - blast furnace Slag 455, high strength 8112, hydrophobic 8043, low heat 269, 12600, pozzolana 1489, rapid hardening 8041, sulphate resisting 12330, white 8042, rotary kilns 8125, refractories for kilns 10607, standard sand for testing 650, Testing apparatus -10078, 5516, 5514, 5536, 7509, 7510, 9350, 5724, 5513, waterproofing compounds 2645, Coal for manufacture 12770, cement concrete 12727, tiles for canal lining .10646, asbestos cement-2098, 1626, 3140, 7639, 11450, bone cement 8681.

11 CHEMICAL WORKS

See Chapter-18 for safety in chemical industry.



Statutory Provisions:

Summary of Sch. 12 and 19 u/r 102, GFR is given below.

Sch.l2, Rule 102, GFR, Sch.l2,Rule 114, MFR & Sch.21, Rule 95, TNFR :

Sch.l2 is applicable to manipulation of sulphuric, nitric, hydrochloric and hydrofluoric acids or liquid ammonia and hydroxide of sodium or potassium or mixture thereof.

Safety measures include acid and fireproof flooring, suitable PPE, safety showers, cautionary notice, containers, crates and rubber-wheeled truck/ trolley to carry the containers safely, suitable tilling or lifting device for emptying jars and carboys, scoop to handle alkalis, use of wooden implements to clean acid tanks for prevention of arsine or H, production, storage of turpentine, carbides, metallic powders and combustible materials not with acids and suitable fire extinguishers. 15 minutes washing is suggested in case of acid or alkali burns.

Sch.l9, Rule 102, GFR and Sch.l6, Rule 95, TNFR:

Part-I Applicability and Definitions:

It is applied to all manufactures and incidental processes carried on in industries listed in the First Schedule of the Factories Act.

The terms defined here include toxic substances, emergency, dangerous chemical reaction, manipulation and confined space.

For other definitions see Chapter-2 and Part 2.1 of Chapter-16.

Part-II General Requirements:

Main points are highlighted as under:

1. **House keeping :**
Spillage to be cleaned. Floors, ways etc. free of obstruction. Easy means of access. Improper use prohibited. No food, drink etc. in the work area. Cautionary notices and instructions regarding fire, explosion, health hazard,' unsafe practices, symbols and colours used on labels. Undertaking

from the workers within one month that they have read the notices and instructions, understood them and would abide by them.

2. **Preparation of new process :**
All hazards of materials and reactions to be studied before staring any process or experimental work. Details of hazards and measures from design stage to disposal stage shall be sent to the CIF before 15 days of commencement.

3. **Authorised entry :**
Only authorised persons shall be allowed to work at dangerous chemical reactions or storage.

4. **Test of Instruments and Safety devices :**
Test before use. Monthly tests by a competent person. To be operated daily to ensure effective working at all times.

5. **Electrical installations :**
Of appropriate type and conforming to IS.

6. **Handling and Storage :**
Containers of adequate strength, labelling, colour - coding, identification of hazard and safe handling method. Use of damaged containers under supervision. Storage or charging should be safe to avoid risk of fire, explosion and toxic concentrations above limits prescribed in the Second Schedule of the Act. Suitable venting to maintain safe levels in vessels and containers. Type and capacity of flooring and compatibility of substances shall be considered. Storage of highly unstable, reactive or explosive material to be limited to the use of 2 months. For excess, permission of the CIF is necessary. The CIF can direct to lower the limit of 2 months if more safety is required. Standby arrangements for emergency transfer should be equal to the biggest container. Non metallic vessels should be strong and independently supported.

7. **Isolation:**
Quick isolation facility with indication required.

8. **Personal Protective Equipment:**
They should conform to IS, should be in clean, sterile and hygienic condition before issue. Information to workers for their use. For any doubts regarding appropriateness, the decision of the GIF shall be final.

9. **Alarms :**
Audible and visible alarms in control room as well as at strategic locations for process correction to control the parameters. They should be checked daily and tested every month. The CIF has power to direct.

10. **Control of Escape of Materials :**
Enclosure, by-pass, exhaust, vacuum etc. required to control the escape and spread of hazardous chemicals. In case of failure of such system, immediate steps necessary to stop further escape and bring down to safe level. The escaped materials shall be diluted with water, air or suitable agent or treatment.

11. **Devices for Dangerous Reactions :**
Automatic and/or remote control arrangements. In case of their failure automatic flooding, blanketing or effective arrangements should come into operation.

12. Testing and Repair of Plant & Equipment :

Test by a competent person before first use. Then periodic test at 2 years interval, or after repair. Detailed precautions are prescribed in para-15 of the Schedule in respect of pressure or reaction vessels.

13. Staging:

Structure erected for maintenance, repair or for entering into confined space should be safe and with access with hand rails. Toe board to work at a height of 1 mt or more.

14. Seating arrangements:

Should be safe to prevent risk of exposure to toxic, flammable & explosive substances.

15. Entry or work in Confined space :

Identify hazards and safeguards. Follow work permit system. Before testing wash, clean, neutralise or purge the space and provide forced ventilation. Test for safe entering. Education,; training and use of PPE for rescue, resurrection and first aid. Work under supervision. A log book of such work should be maintained and shown to the Inspector on demand.

16. Maintenance work etc.:

All such work including cleaning of empty containers of hazardous chemicals, shall be done under safety work permit system and by the trained workers under supervision. Place of such work shall be cordoned off for safety of others.

17. Permit to work system :

It should be under supervision of knowledgeable and responsible person. Clean the work place by washing, purging etc. Then isolate it from other parts throughout the period of work. Develop predetermined work procedure for safety. Physical fitness of the person is necessary. He should be informed about the correct work procedure. Rescue, resurrection and first aid arrangements should be in ready condition for use in emergency. Approved PPE shall be used. Restore the original condition after completion of the work.

18. Safety of Sampling Personnel :

This should be ensured by safe procedure and use of approved PPE.

19. Ventilation :

Adequate ventilation at all times in process area to avoid any harmful concentration.

20. Emergency Procedure :

Should be developed as prescribed in para-23 of the Schedule and must be rehearsed every three months. They include identification of all possible emergencies (which should be reviewed every year), arrangements for outside help for rescue, fire fighting and medical facilities, warning arrangements (its effectiveness should be checked every month), alternate power supply, safe close down procedure, evacuation of persons and its training to workers, information to doctors and precautions against danger due to effluent. Deficiencies to be corrected. Ten percent workers should be trained in the use of first aid fire fighting equipment. The chemical identity (with antidote) should be furnished to the doctor for emergency or first aid treatment to exposed person. For On-site and Off-site Emergency Plan see Part 7 of Chapter-19.

21. Dangers due to Effluents :

Gas evolution due to mixing of different effluents should be prevented. Effluents causing poisonous gases should be trapped and rendered safe by independent drainage.

Part - III : Fire & Explosion Risks :

1. General:

Fire hazards area classification should be as per IS. Spark generating machines, equipment, fittings etc. not permitted in fire prone area. Hot pipes either outside the plant or be protected. Soles of footwear, wheels of trucks or conveyors and tools shall be of nonsparking type. Smoking prohibited. Notices to that effect. Pipelines carrying flammable/ explosive substances shall be protected, examined once a week and record kept of defects and repairs.

2. Static electricity:

Plant, machinery, pipelines, belt drives, receptacles of flammable liquids etc. shall be earthed and humidity be regulated. Mobile tankers to be earthed before filling and discharge. Lightening arrester shall be maintained where necessary.

3. Process heating :

Contact of flammable vapour and open flame should be prevented. Heating should be safe and automatically regulated below danger point.

4. Leakage control:

Bund/dyke surrounding storage vessels of flammable liquids. Fire fighting appliances near such vessels. Waste material contaminated with flammable substances be disposed off safely under supervision.

5. Safety valves and Pressure gauges :

Be fitted on stills and vessels containing gas pressure above atmosphere and maintained well.

6. Fire fighting system :

Where workers exceed 500, trained fire fighting squad of more than 8 persons available at any time and consisting of watch and ward personnel, fire pumpman, departmental supervisors and trained operators for fire and emergency services is required, the squad personnel be provided with protective clothing and equipment. Muster roll of duties be maintained. Telephones should be inter-linked with pump room, main gates and storage area.

Part-IV : Toxic Risks :

1. Leakage & Drainage :

Construction to prevent, segregate or localise escape of toxic release. Bund, dykes and catchpits below pipe joints to collect leakage. Drainage leading to collection and neutralisation or treatment tanks for safe discharge.

2. Vessel covers :

Be provided to avoid physical contact. Fence height 90 cm. or more.

3. Exhaust arrangement;

Required on gas evolving processes and be interlocked with process control where possible. In case of its failure, the process should automatically stop.

4. Work benches :

Of smooth impervious surface and be washed daily after work.

5. Waste disposal:

Non absorbable receptacle with tight fitting cover to collect waste or rejected material soiled with toxic substance. It shall be destroyed by burning or other safe way under supervision. Empty containers be cleaned before disposal.

Part-V : Special Provisions :

Here precautions have been prescribed for following specific processes- .

1. Nitro or Amino processes.
2. Chrome processes.
3. Use of Glass vessels.
4. Chlorate manufacture.
5. Use of plastic vessels and equipment.

Dust or fume control and antidote methylene blue injection are suggested for Nitro or Amino processes.

Exhaust draught, washing facilities, weekly inspection of hands and feet and skin ointments are required for chrome processes.

Wire mesh covering and spillage removal are necessary for all processes in glass vessels.
Chlorate manufacture requires use of hard, smooth, non-combustible surface or vessels, water showers and daily cleaned PPE.

Plant and equipment made from reinforced plastics should be standard (IS), strong against loads, pressure tested by a competent person and not allowing over filling or over loading.

Part-VI: Welfare Amenities:

1. **Washing:**
   One tap for every 15 workers with liquid soap and nail brushes. They should be separate for males and females.

2. **Special bathing:**
   Are required for workers engaged in processes of nitro or amino compounds, chrome, tar, cyanide, cyanate or cyanogen compounds, bleaching powder, chlorine, nickel and its compounds or their derivatives. The CIF has power to direct other industry also. 1 bathroom for 25 workers. Bath necessary at the end of shift.

3. **Mess Room:**
   Required for factories employing 50 workers or more with good ventilation, furniture, drinking water and washing facilities.

4. **Cloak room:**
   Two lockers for each worker, one for work clothing and another for personal clothing.

Part VII : Duties of workers :

Workers shall not make any safety device, guarding or fencing inoperative or defective. They shall report malfunction or defect of machinery, equipment etc. immediately, use PPE, co-operate in emergency duties, undergo medical examination and not do any unauthorised work to cause risk t themselves or others.

Part VIII : Restrictions on young persons

The CIF may by an order in writing, restrict c prohibit employment of women and young person below the age of 18, considering their health and safety aspect. Then such workers should be provide' with alternate work not detrimental to their health c safety.

Refer following schedules also for specified chemical processes :

Schedule No. u/r			Process
102 GFR	114 MFR	95 TNFR	
2	2	2	Electroplating
3	3	3	Electric accumulators
4	4	4	Glass manfacture
5	5	5	Grinding & Glazing of metals
6	6	6	Lead & lead compounds

8	8	8	Air/steam blasting
10	10	17	Chromic acid or chromates
12	12	21	Acids or Alkalis
14, 22	14, 19	26, 30	Carbon disulphide
15	15	29	Pesticides
16	16	18	Compression of O_2 & H_2 by electrolysis of water
18	-	19	Stone & free silica
21	21	23	Oils, fats and solvent extraction plants
24	-	-	Gas welding & cutting
-	18	25	Manganese & its compounds
-	-	10	Cellulose spraying
-	-	11	Graphic powdering
-	-	13	Cashew-nut processing
-	-	14	Coir & Fibre factories
-	-	24	Fireworks & Match factories
-	-	30	Rayon by viscose process

IS : See Chapter-18 exclusively for safety in chemical industry and its Part-5 for IS listed therein.

12 CLOTHING INDUSTRY

Garment making is an old and universal industry. Hazards are hand injuries, cuts, burns, crushing, fire and chemicals. Preventive measures include :

1. Fire safety (see Chapter-13) and safe means of escape.
2. Good housekeeping (see Chapter-8).
3. First aid (see Chapter-26).
4. Guarding of circular knives of portable cutting machines, power presses, needle and drives of sewing machines, under-bench shafting. Various types of needle guards and press guards (two hand control not fully safe) are available.
5. Good earthing and ELCB of portable electrical power tools including irons.
6. Dust suppression and fume control of formaldehyde resin and toxic solvents.
7. Ample air space, good ventilation and temperature and high standards of illumination.
8. Well designed seats for normal posture and reducing fatigue of scapular, dorsal and lumber muscles. Adjustable seats and backs are necessary where more than one shifts operate. Ergonomic designs are safe.
9. Noise control in zip fastener chain production plant.
10. Pre and post employment medical examinations, lunch/rest rooms, washing and sanitary facilities and
11. No exploitation of any kind where girls, women and illiterate workers are employed.

IS : Washing machine 6930, lockers – metal 3314, wooden 5923, clothing - conductive for live working at 800 KV 13771, leather protective 6153, safety industrial 8990, stains removal 11210, clothessize designation 10015, body measurement sizing systems 10397, collar-white, handloom 2715.

13 DAIRY PRODUCTS INDUSTRY

Milk, cheese, curd, butter, ghee and milk powders are widely used. Their industrial manufacture should include :

1. Machine guarding of separators, centrifuges (with interlocking), rotary churns with bar fencing interlocked with churn drive unit, icecrushers, cheese graters, bottling or filling machines, nip between conveyor drums and pulleys etc.
2. Safety of boilers, steam receivers and pressure vessels.
3. Toxic hazard control of refrigerant used. Respiratory and other PPE are necessary.
4. Non-slip floor, non-slip footwear, cleanliness, good housekeeping, fixed stairs and platforms with hand railings and guarding of open vats and vessels.
5. Chemical hazard control for acids and alkalis, use of PPE, first aid and medical care.
6. Double insulation and earthing of electrical machines and tools.
7. Explosion relief vents and temperature control in milk spray drying chambers to avoid fire and explosion.
8. Veterinary medical supervision, personal hygiene, good washing facilities to prevent animal infectious causing brucellosis and bovine TB.

See Part 10.9 (Micro-organism Rules) of Chapter28 for some statutory provisions.

IS : Dairy- floor finishes 7956, equipment, cleaning and sterilising 5253, industry '- rubbers 6450, tests 1479, effluents guide 8682, laboratories, layout 2981, thermometers, floating 1672, farms, cattle sheds 6027.

14 ELECTRONICS INDUSTRY

The use of electronic items is day by day increasing in industry, at homes and at many places. Their manufacturing should include:

1. Exhaust ventilation for fumes of lead, zinc, rosin etc. and also for molten-solder tanks.
2. Eye protection for organic peroxide hardeners and respirators for quartz flour, epoxies with phenol compound and airborne concentrations.
3. Prevention of flammable or explosive mixtures of solvents and source of ignition.
4. Exhaust ventilation for printing process.
5. Acid resistant and non-slip flooring, exhaust ventilation, eye bath and PPE in etching processes. Use closed containers for etching liquids.
6. Good industrial hygiene.

IS : Electronic apparatus, safety requirements 616, climatic and durability tests 589, .gas lighters 9000, equipment - environmental tests 2106, reliability testing 8161, 7354, safety in use , maintenance, manufacture 11743, measuring apparatus, safety requirements 9858, weighing systems 9281, 11547, buzzers 12825, flash apparatus safety 12274, flashers 13135.

Electronic ear protectors 9167, assessment of noise exposure 7194, radiation protection for X-ray tube, radio transmitting equipment, safety requirement 10437,6970, 6567, safety code for radiographic practice 2598, safety of data processing equipment 10422, Hand/foot contamination monitors 11869, Fire hazard testing 11000, protection against ionising radiation 11868.

15 ELECTROPLATING INDUSTRY

This electrochemical process of surface treatment uses chemicals and direct current source for electroplating of many components to protect against corrosion, to improve surface properties and decorative effects. Washing and galvanising are also carried out.

The electrolyte solutions may be acidic, alkaline o: alkaline/cyanidic. The safety measures include:-

1. Control against irritant and toxic chemicals acids, alkalis, dust, gases, fumes and vapouri of organic solvents.

2. Control against electric current with good earthing.

3. Ventilation system to carry exhaust air at a low level and supply of fresh air from upper level

4. Local exhaust ventilation near mechanical cleaning, polishing and grinding. Ergonomic designs are necessary. Aluminium dust must be collected in wet trap to avoid explosion.

5. Iron and aluminium should be ground in separate units.
6. Goggles, gloves, respirators and other PPE necessary.

7. Sucking off heavier solvent vapours from below (where they are condensed) near degreasing baths which should be installed with 1 mt safety zone between the worker and the edge of the bath. Bench ventilation is also necessary for the after treatment of degreased parts. Benzene should not be used.

8. Protection against acids and alkalis in pickling process. Nitrous fumes and HF fumes must not be allowed in workroom. Their proper exhaust is necessary. Water showers and eye-washers for treatment of burns and acid-proof PPE necessary. The acid should be poured into water while stirring continuously, not the other way.

9. Cyanide poisoning may be fatal by breathing or skin contact. The process must be in closed condition. The first-aid measures must be ready. Removal of contaminated clothing, washing with water and fresh air or oxygen treatment will be helpful. Lunch should not be allowed in work room. Optimum hygienic conditions necessary.

10. Chromium plating can cause burns, ulceration, nasal perforation and eczematisation. Powerful exhaust ventilation with maximum closing surface hood and acid-proof PPE are necessary. Exhaust ventilation at the rim of the bath is most effective. Air extraction per cm^2 bath surface should be @ 1800-2700 m^3/h. Non skid floors or plastic duck-boarding, electrical safety (see Chapter-11) and environmental and biological monitoring are necessary.

Statutory Provisions:

Schedules 2, 10, & 12, u/r 102, GFR are relevant. Summary of Schedule-2 is as under :

Applicability:

This substituted schedule is applicable to electrolytic process which means electrolytic plating or oxidation of metal articles by the use of an electrolyte containing acids, bases or salts of metals such a chromium, nickel, cadmium, zinc, copper, silver, gold etc.

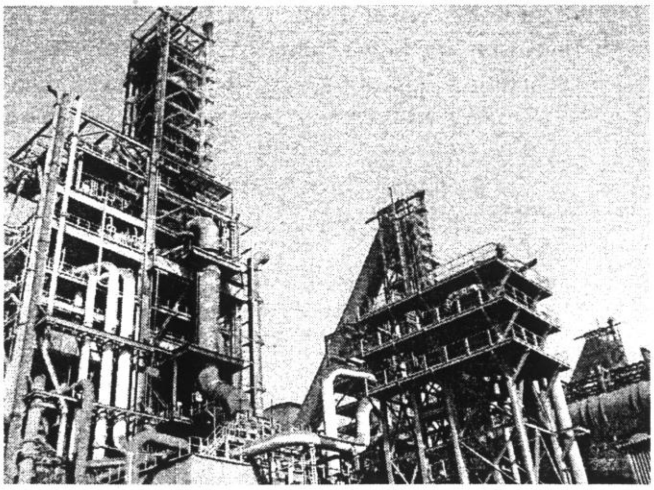
Safety Measures prescribed:
1. An efficient local exhaust draught near vapour origin, preventing the vapour to enter into anyroom or work place.
2. Child, adolescent or Women are prohibited to work at a bath.

3. Impervious floor. It should be washed daily.
4. Waterproof aprons, bibs, rubber gloves, rubber boots, chemical goggles and accommodation to store and dry such PPE of the workers.
5. An undercover wash place or wash basin, one tap for five workers working at a time, with spacing of 12 cms. per worker, waste pipe and constant supply of water.
6. Clean towels and soap etc.
7. Emergency shower with eye fountain.
8. Storage tank of 1500 litres clean water for above purpose.
9. Cautionary notice as prescribed.
10 Medical examination of workers by an employed doctor approved by the CIF. Pre employment and fortnightly examinations and their records are prescribed. Barrier cream, ointment, waterproof plaster, emergency cyanide kit etc. should be provided.
11. Medical examination by the certifying surgeon includes pre-employment and periodical six monthly or yearly examination as prescribed. For use of chromium, nickel and cadmium, urine test is suggested. Fitness certificate in Form No. 27. Health record in form No. 20. Unfit person shall be given alternate placement. Re-employment in the same process if the CS declares him fit.

IS : Electroolated coating- - silver 5925. 6267, 1959, 9530, aluminium 9844, brass 11773, chromium 1068, 1986, gold 4252, 3266, lead 1992, nickel and chromium 4942, nickel 12393, 1809, zinc and cadmium 9839, zinc 1880, 2290, 3027, 12519, Corrosion resistance test 9844, 5528, Local thickness testing 3203, Glossary 3554, Equipment 2679, Industry, treatment of effluents 7453, Recommended practice 3655, filter and powder 10472, mechanical polishing of metals 3656, copper salts 487, succinic acid for electroless plating 9909.

16. FERTILISER INDUSTRY

Fertilisers are natural (manure) or artificial. Artificial fertilisers are produced in chemical plants and they may be organic or inorganic, nitrogenous, phosphatic, potash and trace element fertilisers. In the warehousing stage, phosphate. potassium-salt and other dusts are released. In chemical processing plant, air pollution by toxic gases (Fluorine compounds, H_2SO_4, NO, HCI, CO and NH_3, gases) and dust, high air temperature and noise are noticed. Closed and efficient ventilation is necessary. In finishing processes, weighing, bagging and storing, gaseous emissions and fluorine compounds are released. Phosphates and other raw materials contain 10% or more free silica which may cause pneumoconiosis. The dust of soluble fertilisers causes irritation. The safety measures include:



1. Mechanisation and automation of production processes, provision of remote control, careful assembly and safe operation of equipment and heat insulation.
2. Process segregation and walls and floor covering to absorb fluorine compounds.
3. General ventilation, exhaust ventilation of enclosed plant, cleaning of exhaust air and waste water.
4. Education and personal hygiene.
5. Use of PPF and safety showers.
6. Safety and sanitary supervision.
7. Pre and post medical examination including radiographs of the locomotor system and lungs.

IS : Fertiliser - Glossary 1304, sampling and tests 6092, bagged, handling and storage 5985, mixtures 7863, 9024, effluents - tolerances 2590, treatment and disposal 9841, application equipment glossary 9855, Metering mechanism plate type 12599, feed roller type 12613, Urea ammonium phosphate based 8359, nitrophosphate based 7131, seed drills 6316, 6813, Phosphatic fertiliser industry. Limits of emissions 8635. -

17 FIRE WORKS AND MATCH FACTORIES

There are two types of matches, strike- anywhere matches and safety matches which strike only on friction slips. Wood for its splint and phosphorus for its ignitable head pose fire and explosion hazard. There are dust and fume hazard also. Employment of more number of children in poor working conditions and exploitation increase more hazards. The safety measures include:

1. To prevent fire and explosion risk, manual handing should be replaced by mechanical handing, sources of ignition and friction should be eliminated, fire-resisting PPE should be provided.
2. Good house keeping , gangways and exits.
3. Guarding of guillotine, splitting knives, rollers, printing press and other machinery.
4. Prohibition of white phosphorus. Use closed containers.
5. Good general ventilation and local exhaust ventilation near weighing, mixing splint polishing drum and where chromium or lead compounds are used.
6. Strict cleanliness, sanitary and washing facilities for all workers and cloakroom, mess room or canteen to be separated from process room.
7. Good sitting arrangement should be provided.
8. Only adult workers should be employed.

IS : Fireworks - aeroplanes 12975, rockets 12980, match box - paper 3303, safety 2653, 10373, 10374, 9600, log 1140, Match industry, animal glue 13254.

In December 1999, the Central Government declared prohibited production, sale and use of such fire works which cause noise>123 dB within 4 mt from the point of their firing.

18 FOOD INDUSTRY

Food industries include treatment, preparation, conversion, preservation and packaging of foodstuffs. Women employment varies from 20% to 55%. The industry depends upon seasonal raw materials of vegetable or animal origin.. The processes are handling and storage of raw materials, extraction, crushing, separation, centrifuging, filtering, processing, fermentation, cooking, dehydration, distillation and preservation by high or low temperature processes. High-temperature processes include cooking, sterilisation (steaming in autoclave), pasteurisation, smoking and .dehydration. Low temperature processes include cold storage, freezing and deep freezing.

The safety measures include :

1. Nonslip and dry floor.
2. Good housekeeping.
3. Covered pits and floor openings.
4. Good ladders, safety belts, lifelines and safe means of access.
5. Good lighting and ventilation.
6. Safe use of knives and cutters.
7. Treatment of burns and scalds from steam and hot substances. Insulation of hot surfaces.

8. Prevention of explosion of boilers and autoclaves.
9. Electrical safety.
10. Control of airborne concentrations, dusts and explosive mixtures of gas or oil fired ovens.
11. Prevention of health hazards due to caustic, refrigerants, infections and parasitic diseases spread by animals and dermatitis and allergies by organic products. See Part 10.9 of Chapter-28.
12. PPE for protection in cold storage.
13. Personal and industrial hygiene.
14. Good sanitary and washing facilities and Guarding of typical machinery used.

IS : Food poisoning bacteria 5887, 7688, cereals warning 1656, Foodgrain and pesticides residues sampling 11380, Parathion residues 5952, malathion residues 5863, monocrotophos residues 11374, Safe use of -PVC 7288, polyethylene 7277, styrene polymers 7961, Food colours 5346, tests for dye content 6120, dimethoate residue 11021, Sampling and tests 1699, sensory evaluation glossary 5126, effect of packaging 8639, food yeast 3839.

See Part-7 also.

19 GLASS INDUSTRY

Types of glasses are soda-lime-silica glasses, lead potash silica glasses and borosilicate glasses. Regenerative or recuperative furnaces work upto 1500°C. After melting, other processes are annealing (controlled cooling) manual and mechanical blowing, pressing, rolling, float glass process, grinding and polishing, surface modification, pre-stressing for toughened glass and bonding for laminated glass.

Hazards are due to glass breaking and flying, silica, lead alkaline dusts, fuel and exhaust gases, heat radiant energy, glass blowing, heat cataract and noise.

Safety measures include :

1. Mechanisation and automation.
2. PPE against cut injuries, dust, fumes, gases, heat and noise.
3. Good housekeeping and regular monitoring.
4. Exhaust ventilation (for room and furnace).
5. Automatic weighing, mixing and transfer by enclosed methods.
6. Protection against HF fume by polyethylene containers and siphon transfer, PPE, washing facility and magnesium oxide paste.
7. Protection against high heat by screening, water cooled undersuit beneath reflective asbestos clothing.
8. Medical supervision for lead and other poisoning.
9. First aid and X-ray photograph arrangement to detect glass penetration and
10. Good washing facilities.

Statutory Provisions:

Summary of Scheduler, Rule 102, GFR is given below:

Efficient exhaust draught, lead compound and suspension are defined. Exhaust draft is required for mixing of raw materials to form a 'batch', dry grinding, glazing and polishing of glass article, processes giving HF or NH,, vapours, pots or furnace mould processes and all processes involving dry lead compound. In such processes employment of women and young persons is prohibited.

Floors mid workbenches should be smooth and impervious to water, cleaned daily and well maintained where lead compound or silica dust are manipulated.

Other safety measures include safe handling of HF (cylinder made of lead), no food, drinks etc. in workrooms, PPE, washing facilities and medical examination - pre employment and then at every month, with record in Form No. 20.

IS : Glass - Glossary 1382, packing 6945, safety 2553, toughened 6180, sheet transparent 2835, tableware 1961, tubing for laboratory 7374, thermometers solid stem 2480, protector for tubular gauge 5428, condenser 6052, containers - thermal shock test 11930, vertical load test 11539, electrode for direct reading pH meters 6804, glass fibre chemical resistant test 10661.

20 HAZARDOUS CHEMICALS AND PROCESSES

See Chapter-18 for safety in chemical industry and Part-10.8 of Chapter-28 for statutory provisions on hazardous processes.

Statutory Provisions:

Hazardous process is defined in section 2 (cb) of the Factories Act, a list of 29 hazardous process industries is given in the 1st Schedule and detailed provisions are given m Chapter-4A (sections 41A to H) of the Art

See foregoing part II of this chapter for general safety provisions for 'Chemical Works' also applicable to hazardous chemicals and processes.

The Central Government u/s 6, 8 and 25 of the Environment (Protection) Act made the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 (See Part 10.8 of Chapter-28). Then similar Rule 68J was added to the Gujarat Factories Rules 1963 w.e.f. 15-2-95. It was substituted by Notification dated 30-6-2004.

Now sub-rules of rule 68-J, GFR are as under :

Definitions (Subrule-I)

Subrule-I defines hazardous chemical, industrial activity, isolated storage, major accident, pipeline and Schedule.

Disclosure of Information (Subrule-2)

1. This provision is applicable to an industrial activity of hazards chemical mentioned in Part1 'or II of Schedule-1.

2. MSDS specified in Schedule -5 should be prepared for hazardous chemical. It should be shown to workers on request.

3. Labels on containers of hazardous chemical should identify content, name and address of the manufacturer or importer and physical and toxicological data.

Duties of Inspector (Subrule-3)

The inspector shall inspect at least once in a year the industrial activity or isolated storage, send annual status report and check major accident, site, safety report, safety audit report, onsite and offsite emergency plans.

General Responsibility of Occupiers (Subrule-4)

1. It is applicable to an industrial activity of hazardous chemical mentioned in part I or II of Schedule-1 and also to isolated storage containing threshold quantity (or more) mentioned in column-3 of Schedule-2.
2. Identification of major accident hazards and steps to prevent or control them are necessary. Persons working on site should be given ' training and equipment including antidotes necessary.

Notification of Major Accident : (Subrule-5)

1. Inspector and the CIF should be informed within 48 hours of such accident in Schedule-6.
2. The CIF shall inform the DGFASLI and the Ministry of Labour through proper channel.

Application of Subrules 7 to 13 : (Subrule-6)

Subrule No.	Apply to threshold quantity in
(a) 7,8, 12 and 13	Sch- 3, Column – 3 (excluding, isolated storage)
(b) 8 to 10	Sch.-3, Column – 4(excluding, isolated storage)
(c) 5 and 6	Sch- 2, Column -3 (to isolated storage)
(d) 8 to 12	Sch -2, column – 4 (to isolated storage)

Notification of site (Subrule-7)

The CIF should be informed in Schedule -7 at least 3 months before commencing such activity. If quantity of chemical mentioned in column 3 of schedule-2 & 3 exceeds the threshold quantity, it should also be informed subsequently.

Report of the Updated information (Subrule-8)

Information sent as above shall be updated and subsequent updated report shall be sent to the CIF.

Safety Report and safety Audit Report (Subrule-9)

No industrial activity, to which this sub-rule applies, will be undertaken unless a Safety Report is sent in Schedule-8, three months before commencing that activity. Safety Audit report should be sent subsequently. Frequency of safety audit report-internally every year and externally two years.

Updating of Safety Report (Subrule-10)

Every 3 years updated safety report shall be sent.

CIF can ask further information (Subrule-11)

CIF can ask further information regarding safety report or safety audit report.

On site Emergency Plan (Subrule-12)

An occupier carrying an industrial activity to which this sub-rule applies shall prepare and submit to the Inspector and the CIF an On site Emergency Plan in Sch-8A and rehearsal at every 6 months. For its details see Part 6.2 of Chapter-19.

Information to the persons likely to be affected (Subrule 13)

The occupier shall inform persons likely to be affected the nature of major accident hazard and 'DOS' and 'Donts' about it.

Disclosure of Information (Subrule-14)

This is regarding information to other person and his obligation.

IS : See Part 5 of Chapter 18 on Chemical Industry. Hazardous Chemicals - glossary 4155, classification 4607.

21 FLAMMABLE LIQUIDS AND GASES

See Part 8.3.1 and 8.3.2 of Chapter-18 and Schedules 7, 13, 14, 16, 19, 20, 21, 22 and 24 u/r 102 of the Gujarat Factories Rules for statutory provisions pertaining to flammable liquids and gases.

As defined under MSIHC Rules highly flammable liquids and gases are classified as –

1. Flammable gases (LEL upto 13% or explosive range 12%).
2. Extremely flammable liquids (FP<23 °C, BP<35 °Q.
3. Very highly flammable liquids (FP<23 °C, BP>35 "Q.
4. Highly flammable liquids (FP between 23 °C to 60"C)and
5. Flammable liquids (FP between 60 °C to 90 °C).

Difference between heat generated by the ignition source and heat generated by the burning material is called the flammability index. This index of combustible material ranges from 0.5 to 2.1 and that of highly flammable exceeds 2.1.

From flammability point of view, substances having melting (or dew) point above 50 °C are considered as liquids and those having saturated vapour, pressure of 0.3 Pa or more at 50 °C are gases.

Properties of flammable substances are flash point, fire point, auto-ignition temperature, flammable or explosive limits (range), maximum explosion pressure, maximum safe gap, minimum ignition energy, minimum extinguishing concentration, rate of combustion, rate of total combustion, rate of heating and type of reaction.

For the detailed definitions of above properties and evaluation of flammability of solids, liquids and gases, reference No. 1 at the end of this chapter may be studied.

Hazards and Controls :

Highly flammable liquids need low energy ignition source. Flammable gases are like boiling vapours (owing to their boiling point $\leq$ 20 °C)

Therefore both these substances will ignite immediately on contact of a spark or static charge. Hence precautions mentioned in Section-37 of the Factories Act must be strictly followed. These provisions prescribe -

1. Effective enclosure of plant, machinery or process.
2. Removal or prevention of accumulation of flammable dust, gas, fume or vapour.
3. Exclusion or effective enclosure of all possible sources of ignition (this includes static electricity).
4. Explosion relief devices (vents, baffles, chokes etc.) to restrict the spread and effects of explosion.
5. Safety precautions before opening any part or machinery, such as stopping (isolation or blinding) of inflow of flammable substance, reduction of pressure inside etc.
6. Prohibition of welding, cutting, brazing etc. on vessel, tank etc. containing flammable substance without necessary precautions.

Statutory Provisions

Schedule 13 u/r 102, GFR, Sch.23 u/r 114, MFR and Sch.31 u/r 95, TNFR prescribe statutory requirements. Their abstract is as under (G=Gujarat, M=Maharastra & TN=Tamilnadu):

Sch.l3, Rule 102, GFR :

This is regarding manufacture of bangles and other articles from cinematograph film and toxic and inflammable solvents.

Here 'toxic inflammable solvents' mean solvents like acetone, tetrachloroethane, alcohol, denatured spirit, phenol, amylacetate, butyl acetate, diacetone and such other substances which in the opinion of the CIF are toxic and inflammable.

Statutory provisions include -

1. Prohibition to employment of woman and young persons in the storage or process of above chemicals.
2. Medical examination - first within 7 days of the employment and then every month. Record in Form No. 20.
3. Protective clothing including apron and head-coverings.
4. Efficient ventilation in workroom.
5. No smoking and no source of ignition.
6. Flameproof electrical installation and fittings.
7. Smooth and impervious floor and to be washed daily with water.
8. 10 minutes washing time before each meal and before the end of the day's, work.
9. Washing, bathing, cloak-room and mess-room facilities.
10 Fire-fighting appliances, means of escape in case of fire and doors/windows to open outwards readily.
11 Cautionary notices regarding dangers to workers. Contents to be explained to illiterate person carefully.

Sch.23 u/r 114 MFR and Sch.SI u/r 95 TNFR :

This is regarding highly flammable liquids and flammable compressed gases.

Here 'highly flammable liquid' means that specified u/s 14 & 15 of the Petroleum Act, 1934 and which gives off flammable vapours below 32 °C.

'Flammable compressed gas' mean» that defined u/ s 2 of the Static and Mobile Pressure Vessels Rules, 1981.

Statutory provisions include –

1. Safe storage in a fixed tank or closed vessel or a room of fire resistant construction.
2. Enclosed system of pipes, pumps etc. so as to avoid leak or spillage.
3. Leakage shall be contained, drained off or diluted to prevent flammable air mixture.
4. Exclusion of source of ignition by flameproof electric apparatus, prevention of static charge, no footwear with steel or iron, belts without iron fasteners and prevention of ignition sources such as open flames, sparks, hot surface, heat generating reaction and radiant heat.
5. Prohibition of smoking.
6. Fixed and portable fire fighting systems, materials and procedures as prescribed by IS.

IS : Flammable gases and vapours classification 9570, Flammable liquids detection, storage, construction safety 10386, Flammability test for aerosol products 8469, cables 10810, flame spread of products 12777, flame resistant suit 7612, flame photometer 8651, flame safety lamps, gas testing 7577, Flameproof - AC motors for mines 3682, electric lighting fittings 2206, enclosures of electrical apparatus 2148, transformers 11333, Compressed - oxygen 309, hydrogen 1090, argon 5760, carbon dioxide 307, nitrogen 1747, solvent - for paints 82, insulating varnishes 10026, petroleum hydrocarbon 1745.

See also Part 5 of Chapter-18.

22 LEATHER INDUSTRY

Leather is the skin of animals when tanned and prepared for human or industrial use. Leather processing includes cutting and incision, chasing, moulding, embossing, hammering, mosaic formation, trimming, bonding, stitching and dyeing. Industrial safety measures include :

1. Benzene and any aromatic solvents containing benzene should be replaced with substances in the aliphatic series.
2. Toxic concentrations should be controlled by efficient exhaust ventilation.
3. As the solvents may produce fire and explosion, flameproof electric fitting and elimination of sources of ignition are necessary.
4. Dyeing operations should be fully mechanised or enclosed to avoid human contact.
5. Personal protective equipment.
6. Medical check-ups.
7. Guarding of machinery and safe use of knives and hammers etc.

Statutory Provisions:

Summary of Schedule-10, Rule 102,, GFR, Sch.9 u/r 114, MFR and Sch.9 u/r 95, TNFR on liming and tanning of raw hides and skins and incidental processes is given below :

Cautionary notices regarding Anthrax, Chrome ulceration and the occupational diseases listed in the 3rd Schedule of the Act, are compulsory.

Rubber gloves and boots, aprons and leg covering to workers working with chrome solutions or lime work and other PPE to those handling hides or skins are necessary.

Washing facilities of one place for 10 workers, one wash basin-for 10 workers, mess room and cloak room are required. Foods and drink in work rooms are prohibited. Hands of workers coming in contact with chrome solutions shall be checked twice a week and suitable ointment and waterproof plaster shall be kept in a box readily available.

IS : Leather - glossary 1640, clothing protective 6153, garments 12718, chromed buff calf skin 8121, apron 3446, chemical testing, chrome- belt lace 575, high altitude gloves 5866, footwear sampling 2051, gas meter diaphragms 9155, leg guard 3946, oil seals and washers 3020, gauntlets - for steel workers 2574, mittens for steel Workers 2575, welders 2573, harness 580, belting for power transmission 2240, round for small machines 2241, V-open ended, cogged 10022, endless flat for lenix drive system 12854, hydraulic 581, loom-pickers 8546, picking band 1225, shuttle cock caps 4102, laces, footwear 7721, Safety-belt & strap, lineman's 3521, boots for miners 1989, boots for metal industry 3737, shoes for women miners 11225, footwear with moulding sole 11226, 5677, industry effluent 5183, lining 3840, polish wax emulsion 6045, sampling 5868, sandal for men 6493, sole 579, boards for insoles 5867, shoes non-slip 11543, leather cloth vinyl coated fabric 1259, leather roid for electrical purposes 4819, leathers 3840, chemical testing of leather 582, physical testing of leather 5914, utility glove 11230, slickers for leather industry 5712.

23 PAPER INDUSTRY

Paper is a thin felted matrix of interlacing cellulosic fibres made from wood pulp or rags, straw and grass or waste paper.

In making paper, first raw material from wood pulp, west paper or grass is cut in to pieces. Then it is soaked in water to make pulp. Necessary additives and bleaching agents like $C1_2$ or H_2O_2 are passed through the pulp to make it white. It is passed through many tanks and pulper machine. Then homogenous pulp is passed through paper mill where it is run on the felt through wet and dry (hot) processes. A paper film is formed as a result of this process in the paper machine. Then continuous paper is wound or reel and a papci roll is formed. The roll is removed from the re-winder machine and sent to the cutting department. There if is cut in to the required sizes and packed in bundles.

The safety measures should include :

1. Nip guards on various rolls and felt nips of drying and re-winders etc. Interlock guards for the whole in running nip with additional side guards, efficient doctor blades, air feeds, belt feed and well designed hand tools are necessary.
2. Manual straightening of paper should be replaced by mechanical straightening.
3. Sufficient stopping and breaking pushbuttons i.e. switches.
4. Operation with moving machinery at slow speed.
5. Automatic lubrication instead of manual while machinery is in motion.
6. Interlocked door on hopper of the baling press.
7. Pulpers should have strong fencing (railing) to prevent fall into the deep vessel and interlock door near feed point.
8. Interlocked or photo cell guards on guillotine cutters and slitting machine.
9. Keirs, digesters, dryers and boilers should be fully closed under pressure and Rule 61, GFR should be strictly followed. Safety valve, pressure reducing valve or regulator, pressure gauge etc. should be well functioning.
10. Digester drives should be properly locked so that they may not rotate while charging or discharging. Their start-switches should be with keys and properly identified.
11. Steam pipes should be lagged to prevent burns.

12. Bridges and walk ways over and along side the machine should be protected with double railing, toe-boards and non slip surfaces to prevent falls into the machines.
13. Effective fencing at all points where there are chances of falling on moving-machinery or into pits.
14. Adequate stock and use of lifting machinery.
15. Good drainage of wet flooring and cleaning thereof.
16. Guards on straw cutter drives and beaters. Hopper feeder for straw or grass cutter essential.
17. Railing around feed opening over digesters.
18. Guards on grass-beaters and cutters.
19. Guards on all drives, gears, couplings, pulley belts etc. of all machineries.
20. Locking of electric switches where accidental starting may cause accidents.
21. Fencing or guarding on pulper chests, agitator tanks and pump-motor sets.
22. Test all lifting machinery u/r 60 GFR and maintain form No. 8 and 10.
23. Exhaust blowers of steam dryers should run efficiently.
24. Guard of fly-knife (rotary cutter) should be interlocked. It should not open when cutter is moving.
25. Exhaust ventilation near steam exposures or hot environment.
26. Sufficient lighting in congested areas.
27. Enclosures, barriers and absorptive or reactive silencers to reduce high noise levels.
28. Suction and closed ducting to convey flying dust.
29. To prevent chemical hazards of soda, sulphate and sulphite, use hooded ventilation to vent off steam, HF, SO_2, mercaptans, etc. Use mechanical agitation and spraying.
30. Prevent chlorine and ammonia hazards in bleach plant. See Part 8.6.1, 8.6.2 and 17.3 of Chapter-18 for chlorine & ammonia safety. Bleaching should be carried out in a closed system at a negative pressure.
31. Treatment for caustic burns.
32. Many chemicals used are toxic, flammable and explosive for which effective ventilation, careful handling and fire control are necessary.
33. Good washing facilities, cloakrooms and lunchrooms are necessary.
34. Speedy removal of waste paper, pulp, spillage, dusts and good housekeeping are essential.

IS : Glossary of terms relating to paper and packaging 4261, 4661, 7186, relating to paper sacks 9028, terminology 7186, methods of test for pulp 6213 (Part I to 21), methods of sampling and test for paper and allied products 1060 (Part I to 3), methods of test for corrugated fibre board 7063 (Part I to 4), methods of test for smoothness/roughness of paper 9894, Axial (end to end) compression strength of composite cans, tubes and cores, method of test 13975, method of end blow-off pressure test for composite cans 13976, corrugated fibre board boxes for packing and transportation 13228, for exporting glass jars and bottles 9313, for packaging of apples 11844, for packing soaps 10176, fibre board drums 7601, general purpose packing/wrapping paper 6615, grease proof paper 6622, ice-cream cups and lids 10177, kraft paper 1397, packing paper, waterproof bitumen laminated 1398, aluminium foil laminates for packaging 8970, waxed paper 3962, 3963, 7162, 9988, alkali resistant paper 3673, base paper - for carbon paper 3413, for tracing paper 11687, for waxed paper 2991, blotting paper 1396, cover paper 6956, hand made drawing paper 3064, map printing paper 12765, newsprint paper 11688, paper for permanent records 1774, paper sizes 1064, sizes of envelopes 3338, tracing paper 8431, tissue paper 8460, printing paper 1848, cellulosic paper for electrical purposes 9335 (Part I to 3), 2189, paper clip 5650, Cuttings 4356, germination 6671, insulated leadsheathed cables 3961, insulation, tear resistance 10810, photographic 6139, 6650, 10329, sizing, gelatine for 11227, stationery for schools 5195, top gummed 4185, teleprinter page roll 9031, tray 3791, wastage and spoilage guide for printing industry 12000, writing and printing 1848, for computer 12766, for data processing 10557, paper and board impregnated 5134, paper rolls, sizes, 13075, paper green dehydrated 9486.

24 PESTICIDE INDUSTRY

Pesticide is a chemical used to destroy an organism detrimental to human interest. It includes insecticides, fungicides, herbicides, rodenticides, bactericides, miticides, nematocides, moUuscicides. They are generally halogenated (Cyclodienes, Bischlorophenyls, Cycloparaffins, Organo-chlorines and Chlorinated terpenes) or Organophosphorus (Parathion, malathion, TEPP, OMPA, DDVP, abate, ciodrin etc.) type. They are classified as extremely hazardous, highly hazardous, moderately hazardous, slightly hazardous etc. For these classifications and their details including Lethal Dose values see Reference No. 1 given at the end of this Chapter. Strict safety rules are necessary during their processing, handling, packaging etc. Exhaust ventilation and use of PPE are essential.

Statutory Provisions:

Schedule 15, Rule 102, GFR, Sch.l5, Rule 114, MFR and Sch.29,Rule 95, TNFR give statutory provisions for manufacture and handling of dangerous pesticides listed in Appendix-1 to that Schedule. Appendix-11 gives cautionary placard.

The measures include prohibition of employment of women and young persons, air space of 500 m^3 or more per person, efficient exhaust draft on charging, discharging, blending and powder or liquid preparation, sound and sloping floor with gutters and drainage, daily washing, workbenches of stainless steel, waste container with lid and waste disposal by burning, safe disposal of empty containers, no manual or direct handling, protective clothing and their daily washing, medical facilities including doctor and antidotes and medical examination - pre employment, quarterly examination and record in Form 20, GFR additional rest interval of 10 minutes before each meal and before the end of the day's work, washing and bathing facilities with at least 50% bathrooms and 1 place for 5 workers with clean towels, soap and nail brushes, prohibition of food and drink in workrooms, cloak room for clothing and PPE, mess room with incharge person and prior permission o? the CIF to start manipulation of a new pesticide i.e. not listed in Appendix 1.

Sch.l5, u/r 102, GFR defines "pesticides" as agents used for the purpose of destroying or arresting the growth or increase of harmful organism and defines "dangerous pesticides" as those listed in Appendix-1 as under:

Appendix-1, List of Dangerous Pesticides
(Under GFR & MFR both)

Prathion	Mercury compounds
Diazinon	Methyl bromide
Hexaethyl tetraphosphate	Cyanides
Tetrathyl pyrophosphate	Chlordane
Tetraethyl ditripyrophosphate	Endrin
Demeton (systex)	Aldrin
Schradan (OMPR)	Dieldrin
Para-Oxon (E. 600)	Texaphene
Methyl Parathion	Dinitro-o-cresol
Dimefox	Arsenical compounds
Sulphotepp	Cryloite
EPN	Pentachlorophenol
Nicotine or its compounds	Carbojuran

This list gives commonly better to refer the exhaustive Insecticides Act. used pesticides. It is list u/s 3(e) of the

Sch.l5, u/r 114, MFR, defines "dangerous pesticides" as those defined in Sec. 3(e) of the Insecticides Act 1968 or any other substance declared as such by the CIF in writing. List of Insecticides u/ s 3(e) of the Act is very long with addition from time to time.

Sch.29, u/r 95, TNFR does not give Appendix1 i.e. a list of dangerous pesticides but defines dangerous pesticides' as any product proposed or used for controlling, destroying or repelling any pest or for preventing growth or mitigating effects of such growth including any of its formulations which is considered toxic under and is covered by the Insecticides Act, 1968 and the rules made there under any other products as may be notified from time to time by the State Government.

"Manipulation" includes mixing, blending, formulating, filling, emptying, packing or otherwise handling.

Appendix-11, Cautionary Placard is similar in all above three State Rules and is reproduced below:

Cautionary Placard

1. Pesticides are generally poisonous substances.
2. Therefore in rooms where these are handled(a) do not chew, eat, drink Or smoke; keep food or drink away from pesticides. (b) use the protective wear supplied e.g. gloves, aprons, clothes, boots, etc.
3. Before meals or when any part of the body has come in contact with the pesticides, wash with soap and water.
4. Before leaving the factory, take a bath and change your clothing.
5. Do not use any container that has contained a pesticide as a pot for food or drink.
6. Do not handle any pesticide with bare hands; use a handled scoop.
7. Avoid spilling of any pesticide on body, floor or table.
8. Maintain scrupulous cleanliness of body and clothing and of your surroundings.
9. In case of sickness like nausea, vomiting or giddiness, inform the manager who will make necessary arrangements for treatment.

Effects and Controls :

Pesticides and agrochemicals enter into the body through inhalation, ingestion or skin absorption. They are classified as toxic, harmful, corrosive, irritant, flammable, explosive or oxidising. Toxicity is mostly denoted by LD,, or LC,, values. All agrochemicals should be labelled, transported safely and correctly stored in a room (locked and cool). Containers should be opened only after wearing correct respirator (positive air pressure), neoprene or plastic hand gloves, aprons, boots etc. Protective clothing are always essential while handling pesticides. Inhalation of vapour should be avoided. Contact with skin, eyes and clothing should also be avoided. Contaminated clothing should be immediately changed, the entire body .should be thoroughly washed with soap and water. After working with pesticides, shower bath should be taken and clothing should be changed. Contaminated equipment should be cleaned with soap or soda ash.

Local exhaust ventilation on filling line must be effective.

Types of effects may be acute (immediate) or chronic (prolonged or slow delayed). Some common symptoms are - dizziness, headache, shaking and weakness. More toxic effects may cause convulsions, irrational behaviour or unconsciousness.

First-aid treatment includes - removal of affected person to a safe, clean and airy place, washing of the part affected and to put the person in recovery position (slipping on shoulder). On swallowing, vomiting should be induced if person is in consciousness. Medical charcoal and plenty of water may also be 'given.

Effect of organophosphorous pesticides is to reduce cholinesterase level in body and it can be noticed by pin-point in pupils (eyes).

Blood cholinesterase activity test should be carried out every 15 days. If the level is found less than 62.5%, the worker must be transferred to another place where no exposure is possible. After medical treatment and. safe report he can be put back to his plant. But meantime the engineering controls should be provided or revised to eliminate the exposure. Leakage and spillage must be removed. Defect in PPE should be checked and removed.

An Office Circular dated 27-7-1995 of Factory Inspection Office, Bharuch, sent to pesticide factories, seems to be more important and suggests following safety measures :

1. For filling bottles or small containers of liquid, granules or powder, automatic filling machines with closed chamber and attached local exhaust ventilation must be used. Weighing, plugging and sealing operations and conveyor movement should also be automatic and under suction chamber so that a worker has not to touch any thing and no spillage, vapour or dust shall touch his body.
2. To fill barrel or big container a chamber with exhaust hood and ventilation should be used.
3. To contain or collect leaking liquid small bund and pit shall be provided.

   Spilled pesticide should be neutralised or washed with dry clean cloth and stored in a dust-bin with spring-lid. Then it should be safely disposed or burnt out.
4. Workers engaged to shift, move, clean or pack the filled (plugged) container or to clean any spillage, shall be given goggles, long sleeved shirt and pent, good quality rubber hand gloves, waterproof suit or apron, gumboot and air-line respirator. Safety showers and bathrooms shall be provided.
5. Illiterate, untrained and temporary contract workers are exposed to more risk. Therefore such training should be given to them so that they can read or understand the necessary precautions.
6. Pedestal or positive air fan removes the vapour or dust from one worker to another. Therefore it is inadvisable. Exhaust or negative air suction and air-line respirators are the effective remedies. Exhaled air should be passed through carbon bed filter or effective absorber and final vent discharge should be within safe limit.
7. Regular air monitoring at work place, ppm record and leakage checking are necessary.
8. A record of full name, address, signature, date of joining and photograph of all the workers at the time of first employment are useful to detect cases of delayed effects or after-service effects.
9. If pre-employment and subsequent medical examination shows blood cholinesterase level less than 62.5%, that worker should not be employed in pesticide work. If RBC level is also low, the worker should be kept away for 3 months from such process. Sufficient stock of PAN, Atropine etc. (antidotes) should be kept in the factory first-aid centre.
10. The workers must be aware that in case of symptoms (dizziness, headache, vibration, vomit etc.), which doctor they have to approach. They will follow the medical advice.
11. In each shift, qualified and trained supervisor shall strictly supervise the working conditions, work habits, methods, use of PPE, washing, cleaning and no smoking, eating or drinking in work area.

Specified medical treatment is as under :

1. In case of skin contact of-organo-phosphorous, it should be immediately treated with solution of 5-10% ammonia or 2-5% chloramine.
2. Give injection Atropine sulphate according to age, 2 to 4 mg intravenous or intramuscular. Continue this injection every 5 to 10 minutes till pupils size and heart beats become normal.
3. Give injection PAM (2-Pyridine Aldoxime Methochloride) in glucose slowly. Toxogonin is a condensation product of Pyridine aldoxime and dichlorodimethyl ether.
4. Maintain fluid and electrolyte balance.
5. Give antibiotic medicine to prevent secondary infection.
6. Give Frusemide if lungs are swallowed or water filled.
7. If breathing stops, artificial respiration must be tried till doctor comes. The patient should be kept in a cool and quiet place. Give oxygen if difficulty is in breathing. If breathing trouble is more, the victim should be shifted to hospital and put on ventilator.

Personal hygiene - to wash hands and mouth before and after lunch and bathing and changing clothes at the end of the work - is highly essential.

See Part 4.1 & 4.2 of Chapter-28 for Insecticides Act & Rules.

IS : Handling cases of pesticide poisoning 4015 (Part I & 2), malathion- safety code 10872, technical 1832, phorate G 9359, methyl parathion 10630, benonyl 13786, dodine 13784, diflubenzuron 14185, 14186, pesticide common names 885, determination of metalaxyl residues 14161, methods of test 6940, Residues determination in agriculture, food commodities, soil and water - 13830, 13831, aldicarb 10629, aldrin, dieldrin, aptafol 13245, in food 5863, organochlorine in tobacco products 11820, sampling 11380, solid and liquid packing requirements 8190 (Part I to 4), solid packaging 6604, zinc phosphide 9278, aluminium phosphide 9279, kitazin 13788 to 13790.

Packing containers - HDPE bags 8069, polyethylene 9754, aluminium bottles 9503, aluminium containers (5 litres and above) 9445, tinplate cans 9992.

25 PETROCHEMICAL INDUSTRY

This is relatively a recent industry. The plants are modern, mostly automatic and totally enclosed. It uses gaseous, liquid or solid hydrocarbons. Toxic and flammable exposures and high pressure- high temperature reactions pose health, fire and explosion hazards. Proper FFE and PPE should be used. Pre and periodical medical examinations are necessary. Other aspects similar to chemical industry (see Chapter 18).

Statutory Provisions:

Summary of Schedule 7, Rule 102, GFR, Sch.7, Rule 114 MFR and Sch.7, Rule 95 TNFR is as under:

It is applicable to generation of gas from dangerous -petroleum class A (FP<23 ºC). Safety measures include prohibition of employment of women and young persons, two flame traps to prevent flash back from burner to the plant, one trap being nearest to the plant, leakproof valves and pipes, separate well ventilated building for gas generation, proper fire extinguishers for petrol fires, permission of the CIF to manufacture petrol gas, prevention of spills and leaks, warning notice for no smoking and not carrying any matches, naked light etc., no entry to unauthorised person to petrol vessel, flameproof electric fittings, doors opening outside or sliding and repairing of petrol vessel only after steam cleaning and rendering safe for repair.

For Sch.l3 GFR, Sch.23 MFR and Sch.SI TNFR see foregoing Part 21 on flammable liquids.

IS : Petroleum - glossary 4639, hydrocarbon solvents 1745, coke 1448, 8502, gas containers 4093, gas measurement 8818, industry - pipe threads 3333, 9996, flanges, fitting and C.I. pipes 3516, bauxite 3605, jelly for cosmetic industry 4887, meters, accuracy requirements 2801, storage tank, maintenance & operation 9964, fabrication 10987, sampling 1447, test methods 1448, gauging 1518, temperature measurement 1519, filling machine 3047, measurement instrument 3032, vehicle tank for calibration 2383.

See Part 5 of Chapter 18 for other IS.

26 PETROLEUM REFINERY AND LPG BOTTLING PLANTS

A simple refinery carries out atmospheric and vacuum distillation and produce naphtha and limited products. Other refineries have more processing units such as cracking, alkylation, reforming, isomerisation, hydro treating and lubricant processing. A refinery operation includes 7 areas

1. Separation of crude oil.
2. Conversion of hydrocarbon molecules.
3. Treating crude oil fractions.
4. Blending hydrocarbon products.
5. Auxiliary operating facilities.
6. Refinery offsite facilities and
7. Emission and effluent control. .

Detailed safety norms are prescribed by Oil Industry Safety Directorate and known as OISD norms or standards. They are available in such oil industries.

Some OISD standards are listed below.

OISD Standards :

Sr. No.	OISD Code No.	Name
1	105	Work permit system
2	106	Process design and operating philosophies on pressure relief & disposal system.
3	110	Recommend practices on static electricity
4	112	Safe handling of air-hydrocarbon mixtures and pyrophoric substances
5	113	Classification of area for electrical installations at the hydrocarbon processing and handling facilities.
6	117	Fire protection facilities for petroleum depots and terminals
7	118	Layouts for oil and gas installations
8	119	Inspection of pumps
9	120	Inspection of compressors
10	121	Inspection of turbines & diesel engines
11	123	Inspection of rotating equipment components
12	124	Predictive maintenance practices

13	125	Inspection and maintenance of mechanical seals
14	126	Specific maintenance practices for rotating equipment
15	127	History recording of rotating equipment
16	128	Inspection of unfired pressure vessels
17	130	Inspection of pipes, valves and fittings
18	131	Inspection of boilers
19	132	Inspection of pressure relieving devices
20	134	Inspection of heat exchangers
21	135	Inspection of loading & unloading hoses for petroleum products
22	137	Inspection of electrical equipment
23	140	Inspection of jetty pipelines
24	142	Inspection of fire fighting equipment and systems
25	144	LPG bottling plant operations Vol-I Design philosophies
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39	156	Fire protection facilities for petroleum depots and terminals.
40	157	Recommended practices for transportation of bulk petroleum products
41	160	Protection to fittings mounted on existing LPG tank trucks
42	161	Rescue and relief operations involving tank truck accident carrying LPG
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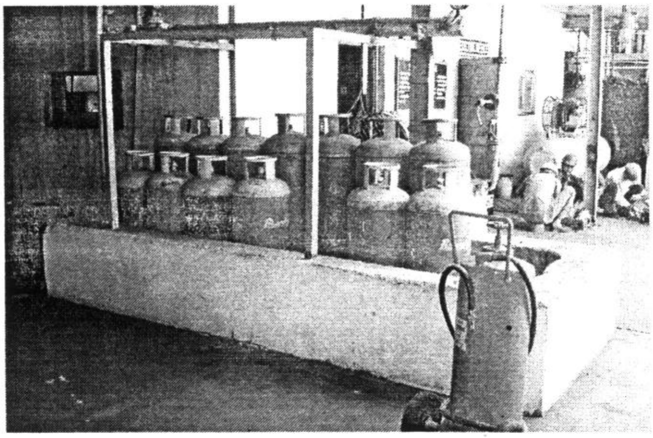
45	169	Small LPG bottling plants – Design and fire protection facilities.

Safety Measures in Petroleum Refinery _

1. H_2S generation should be used to get pure sulphur.
2. Hydrocarbon vapours should be controlled by floating roof tanks, double mechanical seal and leak detectors.
3. Safety distance should be maintained as per OISD, CCE and TAC norms. Petroleum Act and Rules should be implemented:
4. Computerized system to prevent overflow, over filling and leakages.
5. Automatic detection and alarm systems for flammable and toxic gases throughout the plant.
6. Deluge water spray system on tanks, pumps, critical vessels, air coolers etc.
7. Aviation lights on all tall structures.
8. Explosion proof control rooms.
9. Use of HAZOP studies from design to operation stage.
10. Zero effluent discharge and minimization of SOx, NOx, CO, H_2S, NH_2 and un-burnt carbon discharges.
11. Efficient dust control measures for dusts of coal, coke, sulphur and other materials.
12. Efficient communication and fire fighting systems throughout the plant.
13. On-sight and off-sight Emergency plans, SOPs, work permits, safety audits, risk assessment and control measures, safety policy, safety committee, medical examinations of workers, safety training and use of necessary PPE are all essential.
14. Double staircases/safety ladders should be provided on all tall structures where any worker has to go for any work.
15. High noise areas should be marked. Noise reduction program should continue. Ear protectors should be used.
16. All safety devices should be regularly checked and record maintained. The factories Act and Rules should be strictly followed.
17. Isolation valve below the safety valve should be remotely operated (ROV) for high hazard chemical like LPG, Propylene, Benzene etc.
18. On rail/road tanker filling gantries, vapour exposure should not come to workers. Their discharge should be safe. Recovery system should be provided. Interlocking of earthing clamps with loading arm is safer.
19. Travel distance on platform should not exceed 22.5 mt without exit as per GFR.
20. Doctors should take factory rounds to see actual work places and exposures to workers.
21. Services of Industrial Hygienist should be utilized.
22. In laboratory, contaminated air should not be re-circulated. Fume hood sash height should be such that face velocity 0.5 m/s is available.

Safety Measures in LPG Plant :



An infrastructure of one good LPG Bottling plant is described below.

LPG plant is having fully automated fire fighting facility in the form of sprinkler system and hydrant network which is spread all over the plant. For fire fighting purpose, water is stored in separate tanks which last for 4 hrs of fire fighting. For catering water to the sprinkler and hydrant system, fire engines are provided alongwith jockey pumps which automatically maintains a water pressure of 8 kg/sqcm in the hydrant and sprinkler lines. All the Horton spheres. Pump House and Sheds are provided with the sprinkler system which automatically operates if the temperature in these areas rise to 79 °C during an emergency. The operation of sprinkler system will start the fire engines automatically and will pump water in the sprinkler lines. All the facilities are covered with a well maintained hydrant and monitor network which is again fully automatic. Besides this, fire extinguishers of DCP and CO, type are provided near all the facilities as per OISD norms which are checked monthly.

For fire fighting purpose fire organisation chart is prepared which comprises of employees of the plant itself. The fire organisation is basically divided into three teams viz. (1) Fire Fighting team (2) Assisting team (3) Rescue team. All the employees working in the plant have been allocated a job to be carried out during an emergency. For accessing the performance of the teams, Fire Drill is carried out every month and Disaster Drill is conducted once in a year.

Plant is also equipped with fire fighting accessories like fire entry suit, fire proximity suit, water gel blankets, different kinds of nozzles, low temperature clothing, breathing apparatus etc.

General safety measures include :

1. Continuous monitoring of hydrogen sulphide gas, carbon monoxide, ethyl merceptan and other toxic gases.
2. Safe shutdown procedure and start-up procedure should be followed with sequential steps.
3. Good maintenance by blinding or blanking off, electrical lockouts, gas tests and hot work permits.
4. Protective clothing and equipment.
5. Ventilation and air pollution control.
6. Gas monitoring programmes.
7. Leak and fault detection.
8. Control of catalysts hazards.
9. Medical check-ups and industrial hygiene.
10. Fire protection.

IS : Glossary 4639, ventilation in petrochemical plants and refineries 12332, refining industry, effluent treatment 10044, air pollution in petroleum refineries 10179, limits of gaseous emission 8636, LPG 4576, LPG storage installations 6044 (Part I & 2), jointing compounds 3465.

See IS in foregoing Part 25, Part 5 of Chapter18 and Part 3.1, 3.2 and 3.5 of Chapter 28.

27 PHARMACEUTICAL INDUSTRY

Because of strict requirements of Drugs and Cosmetics Act and Rules, generally pharmaceutical factories are neat and clean and the plants are properly laid out. Some safety measures include :

1. Safety from chemicals, chemical processes and vessels as described in Chapter-18.
2. Guarding of all machinery, their drives and dangerous parts.
3. Hood and exhaust ventilation for solvent baths and similar processes.
4. Temperature controls for ovens and dryers.

5. Extremely sensitive methods of sampling and analysis.
6. Medical check-ups.
7. Good manufacturing practice i.e. GMP (See Part 2.11 of Chapter-19).

Mostly ovens and driers are used in pharmaceutical or bulk drug industries. Statutory provisions for them are as under.

Rule 68G, GFR, for Ovens and Driers provides as under :

This rule is applicable to ovens and driers operating at a temperature higher than ambient temperature and in which flammable/explosive air mixture may be evolved in an enclosed structure. It is not applicable to those of capacity below 325 litres and used in laboratories or kitchens.

1. Separate Circuit:
   Separate electrical power supply with isolation switch should be provided.

2. Design, Construction, Test & Examination :
   (1) Proper design on sound engineering practice, good construction, sound material, adequate strength and free from patent defect.
   (2) Testing by a competent person.
   (3) Retesting after repair or alteration and certified by a competent person.

3. Safety Ventilation:
   (1) Centrifugal fan/s for dilution of air mixture and speedy exhaust.
   (2) Safe dilution level is less than 25% of its LEL. 50% of LEL can be allowed if continuous monitor with alarm at 50% LEL is provided which shuts down heating system at 60% of LEL.
   (3) If above ventilation system is not efficiently working or dilution level is not as mentioned, oven or drier shall not be operated.
   (4) Exhaust of ventilation shall be away from the workroom. It should not re-enter through windows/doors.
   (5) Fresh air should be evenly circulated in oven/drier without any. air pocket.
   (6) Throttling damper must allow minimum ventilation rate in its maximum throttling position.

4. Explosion Panels :
   (1) All ovens/driers of more than 0.5 nr" internal space shall have explosion panels (hinged or fragile doors) to release the pressure of accidental explosion.
   (2) Size of such panel - 2200 cm2 per Im" volume of the oven/drier.
   (3) Should open at roof or walls where no person works.

5. Interlocking arrangements:
   (1) Ventilating fans must start first before the feed conveyor starts.
   (2) Failure of ventilating fans will automatically stop the feed conveyor, fuel supply, ignition and the heat source.
   (3) Failure of the conveyor will close the fuel valve, ignition and the heat source.

6. Purging by pre-ventilation:
   Automatic pre-ventilation system will change 3 times the fresh air volume before starting the heating and conveyor feeding.

7. Temperature Control:
Automatic temperature control to ensure its safe limit. Multi stage temperatures will be maintained within the designed limits.

8. Prevention of Dripping:
Dripping of combustible material on heaters or flame shall be prevented.

9. Test, Examination, Ignition & Maintenance :
   (1) Trained responsible person will thoroughly examine all parts at frequent intervals.
   (2) Register shall be maintained for above work.

10. Trained Operators:
Only an adult (above 18 years) and trained operator will be allowed to work on oven/driers.

IS : Pharmaceutical products, packaging, code of practice 14233, plastic containers 7803, rubber closures 3692, safe use in contact with - PVC 7288, 10148, 10151, polyethylene 7277, 10141, 10146, styrene polymers 7961,10142,10149.

28 PLASTICS INDUSTRY

This is a fast growing industry. It has three sectors: (1) polymers and moulding compounds (raw material) manufacturers, (2) processors and (3) machinery manufacturers.

Polymer (resin) Plants should include :
1. Plant design and layout for fire and explosion control, safe venting, storage etc.
2. Control of exothermic reactions and training of operators.
3. Emergency Plan to control fire, explosion and gassing.
4. Prevention of falls (see Chapter-16).
5. Use of PPE.
6. Splash guards.
7. Exhaust ventilation.

Plastic Processing Industry converts bulk polymers into finished articles and includes :

1. Guarding of press platens of compression, transfer, injection and blow moulding machines. Effective or double interlocking is essential.
2. Trip device at rollers and calendars with nip guards.
3. Programmed electronic controls which are more safe.
4. Good housekeeping, cleaning and machinery layout.
5. Static eliminators or earthings to machines where plastic film or sheet travels.
6. Hopper feeders to extruders and granulators. Guards on drives of extruders and insulation of hot surfaces.
7. Fine plastic powder may cause explosive mixture, therefore it should be controlled in an enclosed system with relief panels venting at low pressure (@ 0.05 bar) to a safe place.
8. Fire safety from flammable liquids.
9. Separate storage for peroxides to manufacture glass reinforced plastic (GRP).
10. Exhaust ventilation near toxic and acid fumes, isocyanates, formaldehyde resins, styrene vapour and chloririated hydrocarbons.
11. Safe disposal and burning of plastic waste particularly PTFE and urethanes.

12. Noisy granulators and ultrasonic welding machines should be separated from working area. Coating the machine with sound deadening material and fitting baffles at the feed opening reduce noise. Wear hearing protection.

IS : Industry, glossary 2828, fire safety code 11457, Plastic - for food packaging 10172, container for Vanaspati 10840, 11352, pouches for milk 11805, for edible oils 12724, 12883, 12887, brattice sheeting, unsupported, fire resistant 11884, button 1461, 1465, .chair 13173, clays for ceramic industry 4589, container for fuel 7394, emulsion paint 4511, films for electrical purposes 11298, laminates 5746, measuring cylinder, graduated 10073, mechanical properties test 8543, moulded briefcases 9848, packaging material 10106, packaging terminology 7019, pipes farm drainage 9271, reflectors, lighting fittings 3287, spectacle frame 3693, suitability for food packaging 10171, Surgery - scissors 4275, 4281, needle holder 4245, respiratory 4587, dissecting 4282, forceps 9184, Tests 8543, use in instrument industry 7078, welding, glossary 5687, transparent sheet 9035, 9036, water bottles 8688, wood 423, adhesive tapes 7809, 13262, valves, float diaphragm type 13049, cartridge for shot guns 12497, strain ratio V for sheet metals 11999, PVC lining for chemical process vessels 4682, method of testing 13360, hoses and tubing, bending tests 112656, plasticiser 9591, 3672, 6627, 9572.

29 POLYMER PLANTS

In organic chemistry certain giant molecules such as starch, rubber, plastic .or resin, synthetic fibres, cellulose, proteins are called polymers and plants manufacturing them are polymer plants. Thus rubber manufacturing plant, synthetic yarn (nylon, terylene etc.) unit, plastic, resin or silicon making factory or a starch manufacturing factory can be called a polymer plant.

The polymer (bigger) molecules are built up of smaller units joined together and form a repeating structure. The repeating structure or the recurring unit in a given molecule is called the monomer, and the entire molecule composed of several such repeating units is called a polymer. Thus we can say that rubber is a polymer of isoprene, starch of a-glucose and cellulose of (3-glucose.

Polymerisation process is of three types (1) Addition polymerisation i.e. the combination of monomers either of the same kind or different kind by a process of addition involving no loss of fragments, for example, ethylene - polythene. (2) Copolymerisation involves two different types of monomers, for example, vinyl chloride with vinyl acetate. (3) Condensation polymerisation means the combination of monomers by a process involving loss of a simple fragment or a molecule of water. The terminal units of the polymer chain may be different from the units inside. For example, polyester from a dialcohol and diacid. The alkyd resins are such polymers obtained from phthalic acid and glycol or glycerol. Linear polymers are thermoplastic and cross-linked polymers are thermosetting.

Proteins, starch and cellulosic fibres, plastics and resins are used to make thousands of industrial products. The variety and names of polymers are many, only a few are mentioned below :

Hazards and Controls :

Mostly the polymerisation processes are carried out in totally enclosed system and therefore the hazards are reduced to much extent. Machinery is also mostly enclosed. The hazards are possible from exposure to raw materials, leakage and spillage, dusts and fumes, hot surfaces and radiant heat, noise and vibration and heat and humidity.

Chemicals like formaldehyde andcaprolactam cause burning in eyes, nose and throat. High temperature and pressure of thermic fluid (e.g. Dowtherm) in oil heating system may cause burn and sometimes fire. Extrusion machines have hot surfaces which need insulation to prevent burn injury and hopper feeder to prevent hand contact with screw conveyor inside. Cutting machines for plastic, rubber and other hard substances need safety guard on cutting blade and machine drives. Charging of toxic materials (powder or liquid) need enclosed system with local and room exhaust fans and necessary respirators.

Polyamides used to manufacture epoxy resin are skin irritant. Acrylonitrile used in polyacrylonitrile (PAC or acrylic) fibre is toxic, skin irritant and carcinogenic. This effect was noticed in polymerisation workers. Another chemical dimethyl formamide (DMF) causes digestive effects, abdominal pain, skin effect and pancreatitis to workers exposed to it. (e.g. spinning bath and solvent tanks).

Styrene monomer, acetone (used in cleaning) and organic peroxide catalysts used in making polyester resins may cause fire and explosion. Styrene vapour may cause narcosis (effects on head, nose and throat).

To control such vapour, dilution ventilation and spray booth are necessary. TLV is more critical than the LEL of styrene. (Styrene monomer-phenylethylene or vinylbenzol – C_8H_8 TLV 50 ppm or 215 mg/ m^3 STEL 100 ppm or 425 mg/m^3, LEL 1.1%, UEL 6.1%, FP-33 °C, VD 3.6, poison via oral, ivn). The inhalation dose of styrene can be measured by analysis of exhaled air (gas chromatography).

Solvent storage should be kept away, covered metal containers should be used to collect solvent wastes, electric fitting should be flameproof and smoking must be prohibited. Direct contact of peroxide catalysts should be avoided. Neoprene or plastic gloves are not affected by solvents.

Itching from fibrous glass particles can be minimised by good housekeeping, ventilation, use of long sleeves, barrier creams and frequent washing with soap and water.

Ethylene, propylene and other olefin members to make polyolefins (polymer) are weak anaesthetics at a concentration above 60%. Freezing burns due to liquid propylene and hyperplasia due to prolonged exposure to diolefins have been reported. Aluminium alkyls are flammable in air and explosive in water, their fumes may cause lung damage and in solution it causes burns. Adequate body PPE should be given to workers.

Ethylene, propylene and butylene are gases at room temperature, highly flammable or explosive when mixed with air or oxygen and large fires of olefins are difficult to extinguish. In case of fire, their supply should be stopped, fire should be allowed to burn out and adjacent structures be cooled by water. Small fires may be controlled with CO_2 or DCP extinguishers.

Polystyrene is made by polymerisation of styrene and other monomers. They are flammable. Polymerisation process is highly exothermic and uncontrolled reaction may reach explosive stage. Cooling and pressure relief devices on vessels are essential. Foamed polystyrene is also flammable. Most of the chemicals are toxic. Therefore leakage should be prevented by quick maintenance and enclosed system. Female workers exposed to polystyrene production showed disturbed menstrual cycles, sexual activity, disturbed pregnancy and child birth. Biological indicators are blood styrene level and styrene metabolites in urine. Polystyrene dust may cause weight loss and erythrocyte, leucocyte or hepatic changes.

Polystyrene process should be fully enclosed, automated or remote-controlled. Manual handling should be replaced by mechanical one, leakage should be stopped, local exhaust ventilation on air contamination, respiratory and other PPE to the workers and their medical examinations are necessary.

In making various types of synthetic rubbers, solvents like hexane, styrene, butadiene, chloroprene, acrylonitrile, toluene diisocyanate (TDI) and other isocyanates in making elastomers, ethylene dichloride (EDC), methyl chloride, ethylene, propylene etc. are used. Safety measures are required depending on properties of these dangerous chemicals, their splashes and leakage, pressure release, machine parts, entry into vessels, cuts and burns, fall from height and on the floor.

Health hazards are possible in handling raw rubber containing extender oil and carbon black. During fire CO hazard is also possible.

Workers should be made aware of all these hazards and properly trained. Gas detectors with alarms, welding permit, vessel entry permit, exposure measurement, good ventilation, rubber gloves, eye protection, hearing protection and washing facilities are also required.

Thus depending on a type of polymer plant, a variety of control measures are applicable.

IS : Styrene polymers, safe use in contact with foods etc., 7961, 10142,10149, styrene vinyl benzene 4105, styrenated phenol 7351, styrene butadiene rubber (SBR) - latex 11356, latices, tests 4511 (Part I to 6), tests 4518 (Part I & 2), Polystyrene - for insulation 4671, wall tiles 3463, fixing 4112, sheets 5210, Polybutadiene rubber (PBR), test methods 10016, Polyester resin bath tubs 6411, tank, chemical resistant 10661, Polyolefin - plastic container 7408, fibre analysis 9896, Polypropylene and its copolymers, safe use with food stuffs, drinking water etc., 10909, 10910, thermoplastics 10951, Polyurethane foam - domestic mattresses 7933, insulation, code of practice 13205. PVC - resin 4669, sheeting, flexible 2076, boots, oil & fat resistant 13038.

30 POTTERY INDUSTRY

This is one of the oldest human crafts and many techniques have been changed during centuries. The basic processes of modern industry are preparation of body ingredients, forming and shaping, biscuit firing, glazing, glost firing and decoration. The product is classified as tableware, sanitary tiles and industrial ceramics. The safety measures include :

1. Interlocked guards, mechanical feeding and takeoff at machines.
2. Good house-keeping.
3. Mechanical handling.
4. Control of gas hazards at kilns and dryers.
5. Dust (free silica) control by substitution by dustless process or reducing free silica, isolation from the work room with exhaust ventilation and by using dust mask.
6. Processes of calcining, crushing and mill feeding in a closed system under negative internal pressure to extract dust.
7. Other processes including glazing under hood and exhaust ventilation.
8. Vacuum cleaning and washing of floors and tables.
9. Efficient dust filtration plant not allowing re entry of the filtered air.
10. Dust monitoring and control.
11. Medical examination including X-ray test.
12. Avoidance of lead or restricting to 5% soluble lead in glaze process with exhaust ventilation. Lead in glaze is toxic.
13. Use abrasive rubbers and grinding heads instead of chemicals for cleaning unwanted decoration.
14. Temperature control near kilns and glaze dryers.

Statutory Provisions :

Provisions of Schedule 25 Rule 102, GFR and Sch.lS, Rule 95, TNFR are summarised as under :

1. Applicability:

This schedule applies to all factories engaged in manufacture of pottery except where following articles are made –

(1) Unglazed or salt glazed bricks and tiles.
(2) Architectural terra-cotta made from plastic clay and either unglazed or glazed with a leadless glaze only.

2. Definitions:

The words pottery, leadless glaze, low solubility glaze, fettling, efficient exhaust draught, potter's shop etc. are defined.

3. Efficient Exhaust Draught :

Many processes have been mentioned which cannot be carried out without efficient exhaust draught. These include manipulation of dry and unfritted lead compound, fettling operations, shifting of clay dust, pressing of tiles from clay dust, loading and unloading of saggars, brushing, crushing, dry grinding, cleaning, lifting of materials, weighing, mould making etc. unless the machine is so enclosed or material so damp that no dust can be given off.

4. Other Measures Prescribed

(1) Processes giving dust or using dry lead compound should be separated. Women or young persons cannot be employed in such processes.
(2) Use of leadless glaze or low solubility glaze is permitted and that of high lead content is prohibited.
(3) Potter's wheel (Jolly and Jigger) should have screen to prevent clay scrapings being thrown off.
(4) Damp saw dust or other moist method should be used to prevent flying dust during cleaning of floors.
(5) PPE like overalls, head-coverings, aprons and dust respirator should be given as per need.
(6) One water tap or stand pipe for every five workers with their spacing 1.2 mt or more and towels, soap and nail brushes should be provided. Washing time shall be allowed before each meal and at the end of the shift.
(7) Mess room of size 0.93 m' per person and will facilities of washing, drinking water, warming food and furniture. The room should be clean. well ventilated and in charge of a responsible person;.
(8) Food, drink, pan supari, tobacco etc. should not be consumed in the work room.
(9) Cloak room to put personal clothing and separate arrangements to put PPE.
(10) Medical examination by the certifying surgeon within 7 days from the first employment and thereafter at every 3 months of workers engaged with dry and unfritted lead compound and at one year of workers engaged in dusty processes. Fitness certificate in form No. 27-A shall be granted by the Certified Surgeon. Record in health register. Unfit person can be re-employed after fitness certificate by the certified surgeon.

IS : Clay - ball for ceramic industry 4589, bricks 6165, 5454, 3495, burnt 7556, Hollow bricks for walls and partitions 3952, filler blocks for floor and roof 6061, pipe products glossary 2248, Tiles 3951, 3367, roofing tiles, half round flat 13317, china clay 2840.

Ceramic tiles - 13711, 13712, 13753 to 13756, Tests 7571, 13630, Tower packing 7087, water filter 7402, components for thermocouples and thermometers 8495, Limits of toxic materials 9806,12038.

Ceramic grinding media and lining 7775, Earthenware & dinnerware 2857, 3149, bone china crockeryware 6958, Glossary for - ceramicware 2781, enamelware 2717, stoneware 2839, stoneware, crockeryware 11745, stoneware coatings 2838, colour test for vitreous enamel coatings 8709, methods of test for vitreous enamels and frits 8687 (Part I & 2), 3972 (Part I, Part 2, Sec. I to II), plaster of Paris for ceramic industry 2333, plastic clays for ceramic industry 4589, porcelain crockeryware 3505, powdered talc for ceramic industry 10429, pyrophyllite for ceramic industry 11477, quartz for ceramic industry 11464.

31 RUBBER INDUSTRY

The rubber may be natural from rubber tree or synthetic classified as homopolymers and copolymers. Safety measures include :

1. Interlock guard on the knife of bale cutting machine.
2. Trip guard or sensitive safety bar on horizontal double roll mills for mastication and compound mixing process.
3. Interlocked guard to prevent access to the trapping area near feed hopper of internal mixing machine.
4. Distance guard and feed hopper to an extruder machine. Its fumes should be removed away by exhaust ventilation. Hot surface insulation.
5. Manger type distance guard at the feed nip of calendar machine and fixed guard or electrically interlocked guards on other nips.
6. Interlocked lid of agitator.
7. Solvent vapour removal on spreading machine. Exhaust ventilation, flameproof electric equipment, use of non ferrous tools and antistatic footwear and earthing of machinery are necessary.
8. Guarding of punching, stamping, cutting and slitting machines.
9. Follow Rule 61, GFR for vulcanisers (curing pans or autoclaves). Its lid should be interlocked. Safety valve, pressure gauge, PRV etc. should work efficiently.
10. Interlocked guard on a moulding press. Photo cell guard on a large press. Trip bar at a safe distance.
11. Good ventilation and cool wall colours in moulding plant to reduce heat effect.
12. Exhaust ventilation on buffing.
13. Power press guarding.
14. Guarding of Latex rubber machinery and use of PPE.
15. Exhaust ventilation for nitrous fumes.

Synthetic rubber manufacturing should include :

1. Fire prevention for flammable materials. Well trained fire fighters. Gas detectors with alarms.
2. Handling precaution of pyrophoric catalysts.
3. Handling of volatile monomers and solvents in closed system. Good general ventilation.
4. Self-breathing apparatus to handle large leaks and spills of toxic material.
5. Steam purging of vessel to remove chemical vapours.
6. Personal protective equipment.
7. Washing facilities.
8. Noise control.

Statutory Provisions:

For an abstract of Schedule 4, Rule 54, GFR see Part 4.4 of Chapter-14.

IS : Rubber - industry glossary 7503, acrylonitrile butadiene 8683, aprons for hospital 6407, belting - transmission 1370, conveyor 1891, 14206, Boot 13695, 13995, 5557, knee boots 3738, bottle' for hot water 1867, Compounds - sampling and tests 7086, vulcanised 5192, Hose, wire reinforced 7651, Flooring materials 809, floors code for laying 1197, Footwear - sampling 6368, use at low temperature 14290, antistatic 13575, 13996, Rubber for dairy industry 6450, gasket 11149, for pressure cooker 7466, Gloves for electrical purposes 4770, post mortem 4149, surgical 4148, hawai chappal 10702, seals 13249.

Rubber hose - agricultural spray 1677, air hose 446, hot water 5821, fire fighting 636, chemicals 7654, petroleum tankers 10733, fuel dispensing 2396, hydraulic 10660, oil and solvent resistant 635, water - general purpose 444, sampling and test 443, sand blasting 5894, 6417, steam 10665, suction for fire services 2410, water suction - light duty 2482, 8189, heavy duty 3549.

Methods of test for natural rubber 3660 (Part I to 54).

Rubber - ice bags 3867, insulated cable, current rating 3961, jointing 638, latex 5430, 11001, foam products 1741, lining for chemical equipment 4682, mat for electrical purposes 5424, gaskets foe joints with CI pipes 12820.

Rubber packaging - 5190, styrene - butadiene 11356, symbols 6611, tests 3708, 9316.

Natural- raw 4588, 5599, tests 3660, formula for evaluation 7499, latex based 9827.

Rubber - reclaimed 7490, tests 6306, rollers for offset printing 11610, sheetings, hospital 4135, synthetic, test methods 11720, tests for feeding bottles 3565, tul)es, cycle 2415, Ttfcing for - LPG 10908, general purpose 637, medical use 5680.

Rubber vulcanised - chemical analysis and tests 3400, storage 6713.

Rubber based adhesives for - tubes and tyres 2560 to 2562, PVC tiles 12830.

Rubberised - coil cushioning 11060, coir sheets 8391, fumigation sheets and covers 4810.

See also IS in foregoing Part 29.

32 SHIP BUILDING, REPAIRING AND BREAKING

Ship building and breaking at shipyard or dock, engage many workers and attract provisions of the Factories Act and Rules, though the Dock Workers (Safety, Health and Welfare) Act 1986 (and Rules) is a specific legislation on the subject. See Part 8 of Chapter-28 for Dock Safety Laws.

In addition to the bad weather conditions and climatic effects, the working conditions are also very risky as it involve handling of large sized heavy steel plates, pipes and other articles, fabrication, machining, erection, welding, cutting and work in confined spaces as well as at heights. Welding and cutting in oil tanks have caused many fatal accidents. Raising and lowering of heavy parts and materials and mechanical lifting cause hazards. Falls from different levels, striking against objects, stepping on objects, struck by falling bodies, injuries by hand and power tools, lifting gear, fire, explosion and gassing, burns by hot surfaces, effects of noise and vibration, fumes and eye burning from organic pigments, resin and solvents, loose or temporary wiring, inadequate lighting, dusts from asbestos insulation and shot blasting are also possible. Most of the workers are employed through contractors where training and supervision are poor.

Occupational diseases specific to this industry are : arc eye due to welding, deafness due to high noise, white finger due to vibrating tools, lung irritation, narcosis from exposure to solvent fumes, asbestosis, mesothelioma, carcinoma, asthma, siderosis a banign lung condition due to inhalation of iron oxide dust or flue from welding or burning, dermatitis or skin rashes and cataracts due to ionising radiation and lasers.

Statutory Provisions:

Rule 68H, GFR gives statutory provisions. Its summary is given below :

1. **Applicability:**
   This rule is applicable to "operations" of construction, reconstruction, breaking, repairing, refitting, painting and finishing of ship or vessel.

2. **Definitions:**
   The terms certificate of entry, hot work, naked light certificate, oil, oil tank, tanker, shipyard, stage and staging have been defined. Oil means any liquid having FP below 132 °C and also includes lubricating oils, liquid methane, butane and propane.
   Certificate of entry and naked light certificate are issued by a competent analyst after testing the atmosphere in oil tank to allow a person to work.

3 **Ladders:**
   Ship's accommodation ladders or sound gangways (width more than 55 cm. with each side railing of 90 cm.) of adequate strength and securely fixed should be provided. Rope ladders and boatswain's chairs, ropes, gears etc. should be of sound material and securely attached.

4. **Throwing Down Materials and Loose Articles: .**
   Materials or articles shall not be thrown from a height but shall be properly lowered. When this is not possible, warning notice shall be displayed or work shall be done under direct supervision of an authorised person. Materials left, lying anywhere and likely to fall should be safely collected.

5. **Entry into Confined Space :**
   A space likely to contain dangerous fumes shall not be certified for human entry unless it is properly purged, ingress of dangerous fumes is prevented, sludge or other deposit liable to give off dangerous fumes has been ventilated and tested for adequate air (oxygen) for respiration. If oxygen is insufficient, breathing apparatus and safety belt shall be utilised.

6. **Welding, Cutting and Heating :**
   1. Pipes containing oxygen or flammable gas/vapour shall be safe and properly maintained. They should be securely attached by means of suitable clips.
   2. Pressure reducing valves shall be provided.
   3. Back pressure valve and flame arrester shall be provided in the acetylene supply pipe.
   4. Valves should not open accidentally. They should be securely closed when not in use.
   5. Gas pipes, not in use, shall be kept at the top, safe and ventilated places and may be dis-connected from source if possible.

7. Naked light and Hot work on Oil carrying Vessels:

Normally no naked light, fire or lamp (not being safety lamp) or hot work shall be permitted unless a naked light certificate is obtained and is in force or such work may not produce sufficient heat to ignite flammable material.

8. Cleaning of Oil-tanks:

Before a test for flammable vapour is carried out with a view to issue a naked light certificate, the tank shall be cleaned and ventilated. First volatile oil shall be vaporised, then residual sludge/deposit shall be removed and thoroughly ventilated by mechanical or effective means to remove all oil vapour.

9. Personal Protective Equipment:

Hand protection, goggles, helmets, face shields, screens, safety belts etc. shall be provided to workers as per requirement.

10. Others:

1. No young person shall be employed to clean, break , cut or spray asbestos.
2. An experienced supervisor shall be employed in a shipyard for exclusive observance of these rules.

IS : Safety and health requirements in electric and gas welding and cutting operations 818, ship geometry glossary 8214, ship building, noise level on board 13161, desk machinery 8650, 12719,

Ships - ventilation and pipeline systems 3733, 9423, 9752, window glossary 11914, ordinary 8886, safety glossary 6640, window positioning 12693, window gaskets 8809, air pipe hood 6636, AC requirements 8434, 9114, binnacles - 5289, 4045, cabin ventilator 3941, derricks, 4478, 5521, direction finder 4259, dog-step ladder 8450, doors 4384, electrical installation 10242, eye plates 6203, 6225, fire appliances 3947, flag staff 7723, conventional signs 6737, hydrodynamic terms, glossary 8214, 5314, marine engines, boilers and steel castings 2986, mechanical ventilation 5858, piping system 4693, 7304, propellers 8215, 9126, scupper 5875, 5876, signalling whistle 11608, steel - ladder 6176, structure 2985, wire reel for inland vessels 4659. .

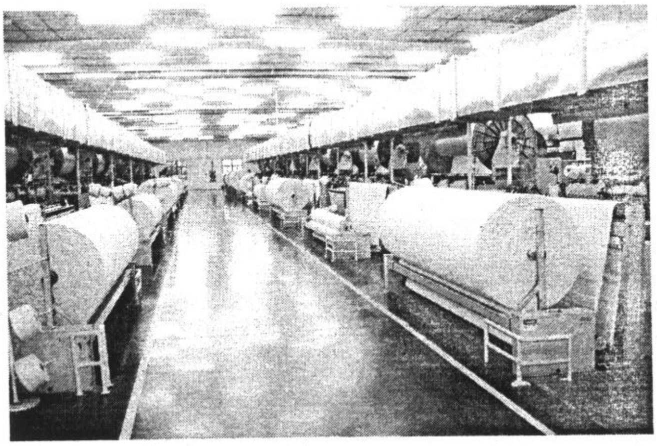
Shipboard - AC system 8649, 9734, indicator lights 9421, lamps 2592, mechanical ventilation 4881, cables 10242.

Ship building - Arc welding 5525, carbon steel forging 3261, cargo gear book 7248, code of practice 13930, vibration 13121, 13633, dimensions guidelines 8712, deck insulation materials 14307, 14336, marine radar reflectors 13708, foam material 14317, distress signals 14270, engine fuel oil piping system 14140, steam traps, guidelines for selection 12794.

Ships - international shore connections 12266, hull, steel plate 5488, structural steel 3039, tools and outfits guidelines 11160, vibration guidelines 13121.

33 SILK INDUSTRY

Silk is a lustrous, tough, elastic fibre produced by the larvae of silk worms and includes the thread of cloth made from it Similar synthetic fibre is known as artificial silk. In industrial use the hazards are similar to those in' the textile industry (see Chapter-21). Shuttle and other guards for looms and good lighting for spinning and weaving are necessary.



IS : Silk - cloth 1687, coating 3356, 3359, evenness 2944, fabric 3357, 3358, 3561, handloom 1583, 1686, khadi - national flag of India 300, Raw test - cleanness 2945, neatness 2946, cohesion 2948, size or count 2942, 2943, grading 2938, serigraphtest 2947, conditioned mass 2940, winding test 2941.

Silk - ribbon tap 10056, sarees 2207, sewing thread for parachutes 3254, webbing 7776, screen printing inks 12530, raw - grading methods 461.

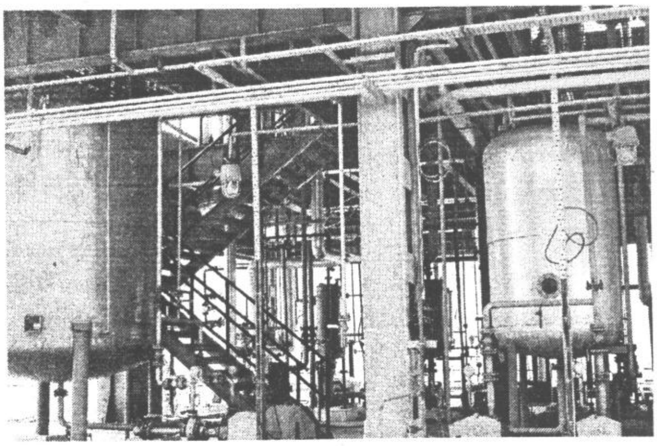
34 SOAP INDUSTRY

Soap is prepared from triglycerides (animal or vegetable oils and fats) by alkaline hydrolysis (saponification). It is a water soluble salt of carboxylic acid and is extensively used for cleaning, washing and textile processing. Safety measures include :

1. Guarding of stamping tools and other machinery. Interlocks and limit switches should be regularly checked.
2. Follow Rule 61, GFR for steam pressure vessels, blow off valve should be used carefully.
3. Prevention of falls by non-slip floor, regular cleaning and good housekeeping.
4. Safe handling of materials and stacking.
5. Rubber gloves, aprons, boots and goggles or face shields to prevent burns from sodium hydroxide, sodium silicate, cresylic acid, inorganic builders (alkali phosphates, silicates, carbonates etc.) and organic builders (starch, cellulose ethers and esters).
6. Lagging of hot pipes and colour coding.
7. Good washing facilities, barrier creams and medical check-ups for dermatitis due to oils or rosin.
8. Temperature near boiling pan should be reduced by vessel lagging, exhaust ventilation and proper roof height. Fencing of vessel and safe platforms are necessary.

IS : Soap - toilet 284, transparent 839, soap stock 12031. -

35 SOLVENT EXTRACTION PLANT



Industrial solvents are generally organic liquids like benzene, hexane, xylene, CS,, petrol etc. They dissolve many substances which may or may not be dissolved in water a fundamental solvent.

Solvents are classified in 9 groups :

1	Hydrocarbons (aliphatic & aromatic)	6	Glycol derivatives
2	Halogenated hydrocarbons	7	Esters
3	Aldehyde and Ketals	8	Ketones
4	Alochol	9	Miscellaneous
5	Ethers		

Uses of solvents are many, such as surface coatings, paints & thinners, synthetic fibres, to make the material soft (plastic) for moulding, extrusion or shaping, to extract oil, fats and medicinal material from seeds, nuts and bones, degreasing, dry-cleaning and for dissolving chemical reagents. It is used directly as raw material in organic synthesis also.

Fire, explosion and toxicity are its main hazards. Less harmful solvent should be selected as far as possible. Local exhaust ventilation to keep the material below its LEL, dyke walls to tanks, flame arrester and cooling system, flameproof electric fitting and equipment, air as well as biological monitoring, alarms and trips, respirators and other PPE, and work permit to work in confined spaces are necessary safety measures.

Statutory Provisions:

Summary of Schedule 21, Rule 102, GFR, Sch.21, Rule 114, MFR and Sch.23, Rule 95, TNFR is given below:

1. Definitions:

Solvent ex traction plan t means a plant where process of extracting oils and fats from vegetable and animal sources by use of solvents is carried on. Solvent is a flammable liquid such as Pentane, Hexane, Heptane used for the recovery of vegetable oils.

Competent person is specially defined for this Schedule. He should be (i) B.E. (Mech.) or B.Tech. with special knowledge of oil and fat with 5 years experience or (ii) a member of Institution of Engineers (India) with 10 years experience or (iii) of qualification accepted by the State Government.

2. Location and Layout:

The plant should be 30 metres away from the nearest locality, 1.5 mt. fencing at a distance of 15 mt. from the plant. Boiler house etc. at a distance of 30 mt. from the plant. If godowns and preparatory processes are within 30 mts. from the plant, barrier wall of non-combustible material and 1.5 mt. height should be at a distance of 15 mt. from the plant. Prohibition to carry match box and open flame inside. Smoking prohibited within 15 mt. from the Plant.

3. Electrical Installations:

They should be of flameproof construction. Metal containers of solvent and non energized electrical equipment to be properly bonded and earthed.

4. Precautions against friction:

Tools, ladders, chains, lifting tackle and footwear to be of non sparking type. Static charge eliminator on belt drive. Clothing of nylon or other fibre capable of causing static charge are not allowed.

5. Fire fighting:

Adequate number of portable extinguishers and automatic water sprinklers or open-head deluge system over the plant are required.

6. Ventilation:

Plant building should have mechanical ventilation providing at least 6 air changes per hour.

7. Venting:

Solvent tanks should have emergency vent to relieve excess pressure in case of fire. Such vents should open at least 6 mts. above the ground so that vapour should not re-enter the plant.

8. Others:

1. Automatic device to cut off steam and to supply cooling water from overhead tank by gravity in case of power failure.
2. Magnetic separators on oil cake feeder to remove iron pieces.
3. Flash evaporator to remove solvent from process waste water located 8 mts away" from the fence but within fenced area.
4. Solvents should not be stored in the plant building. Space of 15 mts within the plant shall be kept free from combustible material. Spillage shall be cleaned immediately. Daily removal of oily rags and wastes etc.
5. Trained operators certified by the competent person.
6. Women and young persons prohibited.
7. Vapour monitoring by a combustible gas detector. Sampling locations to be approved by the CIF. Register is required for record.
8. Examination by the competent person every year. Repairs under the direct supervision of the competent person.
9. Purging (with inert gas or steam) required before opening for cleaning or repairs or introducing solvent after repairs.

IS : Solvent - for paints, sampling and test 82, insulating varnishes 10026, petroleum hydrocarbon 1745.

Solvent extracted - coconut oilcake 3591, cottonseed oilcake 3592, ricebran 3593.

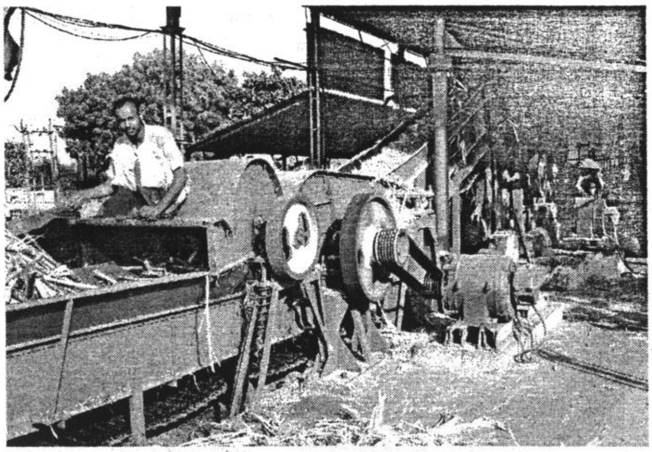
Test for corrosivity of solvent 13643.

See also Part 5 of Chapter-18 and foregoing Part 20 and 21 of this Chapter.

36 SUGAR INDUSTRY

The growth of sugar factories is very wide and mostly in co-operative sector. Except some small Khandsari units, generally the sugar mills are large factories running with heavy machinery and big-sized vessels, employing more than 1000 workers and occupying a bigger area for the mill plant, sugar cane transport vehicles, sugar godowns, bagasse (crushed fibrous waste) stocks and long conveyor belts, molasses tanks, solvent extraction plant if provided, residential facilities for mill workers and offices for other related activities.

The nature of sugar mill machinery pose mostly the mechanical hazards like crush injuries, falls or slipping from heights, falling into pit or hot sugar juice, hurt by falling bodies or sugar bags, fumes and gases (SO , HCI, CO, CO,), steam at many places, sugar cane dust (may cause bagassosis), noise and vibration due to centrifuge machines and vibrating screens, packing machines and large size crushing gears.



In the process, sugar canes are put on feed (rolling) carrier, pushed ahead by steel beaters and crushed in two to three sets of heavy rollers. The initial juice contains bagass fibres, clay, grit, albumen, pectin etc. Bagass fibres cause lung disease known as Bagassosis. The juice is then heated and chemical agents are added to remove impurities and to get saccharose. After clarification (through heating) the juice is concentrated in vacuum evaporators till it precipitates in the form of greyish crystals. The concentrated juice (molasses) contains 45% water. By centrifuging the water is separated and brownish granulated sugar (brown sugar) is filtered. White sugar is made by refining (Sulpher) process. The filtered syrup is evaporated in quadruple effect evaporators, vacuum pans and crystallisers till it crystallises. Centrifugation is again applied to get white crystalline sugar. Vibrating screens are used to separate sugar crystals in different sizes (grades). It is then weighed, begged and sent to the sugar godowns.

The safety measures include -

I Cane Milling Plant :

1. Cane handling platform with gantry and gantry columns (not more than 10 m. apart) attendance platform, approach staircase, sling bar and grab attachment, mechanical/ electrical controls from crane operator's cabin.
2. Fixed sound guards on motor and gear drives of feeder tables, steel structure to withstand heavy shocks, inclined tail end to feed into the main carrier.
3. Cane carrier (1800 mm wide), 3 strands chain (150 mm pitch) and sprockets with heavy guards, hood 'to cover cane knives with inspection door and head-shaft and gears with guards.
4. The cane carrier motors be interlocked with the cane leveller and cutter motors so that the cane carrier stops when either of these motors trips.
5. Cane feeding chute from cane carrier to the crusher at an angle of 50° from the horizontal. The chute length should be more than 3.5 m.
6. Guards on gear and motor drives of cane kicker - a rotating shaft (dia > 125 mm) mounted with more than 20 blades or arms.
7. Totally enclosed reinforced steel hood with suitable swing flaps and bolted top covers on cane leveller with more than 42 knives and cane cutter with more than 52 knives. The knives should be

of specially shock resisting steel with carbide tips or stellited cutting edges. Guard on flywheel of the shaft.

8. Crushing mills may be of following types :
   Based on sugar cane crushing capacity per day-
   For 2500 tonnes-12 rollers-4 steam turbines
   For 3500 tonnes-18 rollers-6 steam turbines
   Fixed guards on mill gearing, flexible couplings and mill rollers (max. speed 18 mt/min).
9. The juice gutter under the mills shall be made of brass or copper lined MS plates or aluminium plates of sufficient strength.
10. Cylindrical whirler type pumps of 75 m3/h at 10 m head, non corrosive, non choking type, and with bronze impellers.
11. Vertical guard or fencing on bagass elevator and conveyor and also surrounding floor or feed opening and horizontal guards or grills on moving slats and bagass scrappers.

    A gangway of open flooring with hand railing alongside the whole length of the conveyor with access ladders at different platforms including boiler control platform.
12. Testing and maintenance of all cranes and lifting machinery as per Rule 60 of the GFR.

II Clarification Plant:

1. Juice heaters with necessary valves, venting and condensate extraction device with collection tanks and safety for steam use. Solid drawn brass tubes for heaters with 42 mm ID, 45 mm OD and total length of tubes not exceeding 4.5 mt
2. Continuous juice sulphitation unit, with lime milk proportioning arrangement, guards on lime slacker motors, couplings and gear drives and stirres drives. SO_2 absorption tower with safe vent, effective stirrer, sulphur furnace with cooling water jacket for vertical gas pipes and scrubbers made of cast iron.
3. Clarifier with flash tank, juice overflow box, scrapper drive, mud overflow box, liquidating pump etc.
4. Vacuum rotary mud filter with bagacillo sifter, recirculation pump, juice trough, filtrate pumps and receivers, mud conveyor belt, juice separator, air blower, cyclone separator for vacuum filters, cake washing hot water pumps and guards for pump couplings and motor drives.

III Evaporation and Boiling Plant :

1. A quadruple effect evaporator with four bodies (vertical tanks) with two syrup extraction pumps (one standby), safety valve in the vapour space to open at 0.2 kg/ m2, pressure and vacuum (compound) gauges, thermometers, condensate extraction pumps, grit catchers, vapour space height more than twice the calandria height, calandria (bottom heating zone) height not exceeding 2 mt, domes and fittings of suitable save-all design, the calandria tubes should be solid drawn with 42 mm ID, 45 mm OD, tubes spacing more than 10 mm. and vapour condenser at the end.
2. Syrup and molasses tanks (13 to 15 tanks), bund or dyke, heating coil to molasses tanks, wash out connection to each tank, wash out gutter with suitable valves, working platform with handrails and approach stairs along the storage tanks. One molasses dilution tank with stirrer, water and steam connection is also necessary.
3. Vacuum pans, condensers and injection water pumps requirement is as under :

For plant of	Vacuum pans	Condensers	Water pumps
2500 T	5	6	6
3500 T	7	8	8

Vacuum pans are calandria of low head rapid boiling type with steam tubes (brass), compound gauges, thermometers, various pipelines and fittings, connections with crystallisers and multi-jet condensers, heavy molasses and hot water connection through nonreturn valves, guards on stirrer drives and gears, the injection water pumps - centrifugal and directly coupled, are all necessary.

IV Cooling, Curing and Grading Plant :

Heavy U-type air cooled and water cooled crystallisers are required with stirring arrangement, guards on stirrer and gear drives and centrifugal machines (15 for 2500 T plant and 20 for 3500 T plant). Superheated wash water or steam connection, timer controlled automatic brakes, solenoid and pneuma,tic valves, ploughing speed not exceeding 60 rpm, connection with magma mixtures, guards on magma mixture drives, guards on pug mill drives, reduction gears and air-compressor drives, steam connections with NRV for magma and molasses lines, sugar melter, grass hoppers and conveyors, hot and cold air blowing, sugar elevators and graders (vibrators) with dust catching arrangement, sugar weighing machines, bag stitching machines, molasses weighing scale and final molasses storage tank (3 to 4) each of 4000 m" capacity as per IS specification.

Other plants viz. Boiler and steam generating plant. Power generating plant and Miscellaneous e.g. reducing valves, pipelines, supporting structure, service tanks, water pumps etc. also need due consideration.

Dust, fume and gas extractors, noise and vibration dampers and medical examination of workers are also required.

IS : Sugar laboratories 1679, 5527, godown construction 4772, vacuum pan grading 498, filter cloth 1178, inter-carrier chains 9069, sprockets 12198, effluent treatment 4903, crusher 1973, 6983, 6997, juice hygienic code for sale 8124, stripper 7789.

Sugar confectionery- hard boiled 1008, sampling and analysis 6287, cube 1168.

37 TOBACCO INDUSTRY

Tobacco is manufactured into biddies, cigars, pipe, chewing tobacco or snuff. Some factories are large and fully mechanised but many are small factories employing mostly female workers. Safety measures include

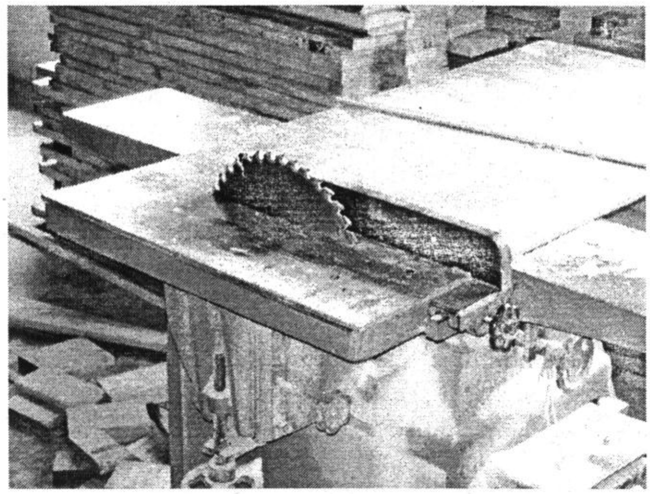
1. Guarding of all machinery moving parts, drives, shafting, gearing and cutting knives.
2. Nip guards to conveyors and rollers.
3. Prevention of explosion due to tobacco dust.
4. Local exhaust ventilation to dust sources (respirable tobacco dust is 0.3 to 3.6 mg/m").
5. Good housekeeping and vacuum cleaning.
6. Good sanitary and washing facilities, personal, hygiene, protective clothing, dust masks and medical supervision.

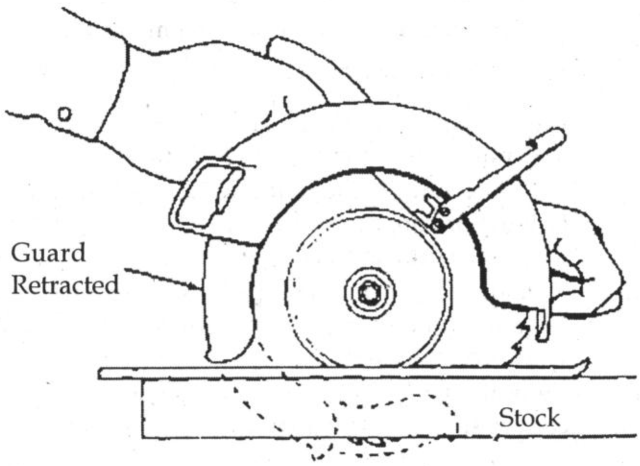
IS : Tobacco - glossary 10335, analytical test 7753, chewing (zarda) flake 2344, minced 3041, moisture determination 9379, packaging code 10106, packing seaworthy 4698, paste hookah 14332, sampling 8600, Virginia seedcake 10670.

Tobacco seeds - 3380, grading 8443, oil 5614, test 5643.

38 WOODWORKING INDUSTRY

Woodworking industry includes wood cutting in sawmills, wood preservation and treatment and making of panels (veneer plywood, chipboard, hardboard), furniture and other products by using woodworking machines and tools which are mostly dangerous and need strict guarding. The safety measures include :





1. Circular saw guarded with adjustable riving knife, guard hood with vertical and horizontal adjustment, under-table cutter guard and drive guard, readily replaceable blade aperture insert to prevent the entry of waste, intermediate guide or rip guide to prevent jamming, push stick with handle and stop/start switches within reach.
2. Guarding of chain saws and hand saws (vertical or horizontal) including blade wheel (drive and return wheel) guarding, blade guarding, adjustment and maintenance, sawdust exhaust ventilation and collector, effective brakes within reach and guarding of drives and other dangerous parts.
3. Guarding of surface planner, other planning machines and vertical spindle moulders and routers with effective and adjustable tool guards with exhaust ventilation with close hood to collect saw dust and shavings.
4. Tools well sharpened and balanced and vibration damping base to minimise noise.
5. Electrical equipment properly earthed and start/ stop switches within reach.
6. Exhaust hood or booth for belt, disc or orbital sander to collect saw dust.
7. Exhaust ventilation and spray painting booth while surface finishing with solvents and toxic chemicals.

8. Prevention of fire hazard by close dust collectors as stated above, regular cleaning and maintenance of machines, prohibiting smoking, good house keeping and using fire fighting equipment.
9. PPE like leather aprons, goggles and gloves.
10. Medical check-ups for dust effects.

For an abstract of Schedule 3, Rule 54, GFR see Part 4.4 of Chapter-14..

IS : Woodworking machines - safety conditions 8964 (Part I to 24), terminology 11011, working dimensions 7287, working level heights 7229, mortising machine 7266, 7286, moulding machine 7254, planning machine 7289, 7296, routing machine 8107, surface planning machine 7267, thickness planning machine with rotary cutter 7249, table handsaw machine 7227, slot mortising machine 7266.

Woodwork - fire safety 6329, aluminium paint 3585, Wooden packaging - terminology 6703, timber 6662, packing cases 1503, 6729, 8358, 4834, 3728, 8725, 8726, 7698.

Wood preservatives - 4873, 218, 4833.

Industries may be endless, as they are ever increasing with the human needs. A few are stated above with more than 500 safety measures which give sufficient knowledge to find out safety measures for other industries also. Chapters' 14,18,20,21 and 22 cover major part of machine guarding and safety aspects of all mostly used processes and provide a data bank for effective safety inspection of any industry.

E X E R C I S E

1. What are the health hazards of pesticides and methods of their control?
2. What are the main health hazards in cement industry? Briefly discuss the safety measures of safe guarding the health of workers in this industry.
3. State the main hazards which are generally encountered in the storage and handling of solvents in a petrochemical plant. Give their important preventive and control measures.
4. Explain the statutory provisions on manufacture of:
   (1) Asbestos. (2) Benzene. (3) CSz (4) Glass. (5) Flammable liquids and Gases. (6) Rubber. (7) Pottery. (8) Wood working. (9) Solvent Extraction plant.
5. Explain in details the health and safety measures on Chemical Works OR Hazardous Chemicals and Processes.
6. Write short notes explaining safety measures :
   (1) Types of industries needing attention. (2) Cement industry. (3) Electroplating industry. (4) Fertiliser industry. (5) Leather industry. (6) Paper industry. (7) Plastics industry. (8) Polymer plants. (9) Ship breaking industry. (10) Sugar industry. (II) Carcinogenic Dyeintermediates (12) Tobacco industry.
7. Enumerate safety measures required in -
   (1) Food industry. (2) Match factories. (3) Electronics industry. (4) Automobile industry. (5) Beverage industry. (6) Brick or Tile industry. (7) Clothing industry. (8) Dairy industry. (9) Petroleum refinery. (10) Ovens & Driers. (11) Soap industry (12) Silk industry.

Reference and Recommended Reading

1. Encyclopaedia of Occupational Health and Safety, ILO, Geneva 2
2. Accident Prevention Manual for Industrial Operations, NSC, Chicago, Illinois.

3. Loss Prevention in Process Industries (Vol. I and 2), Frank P. Lees, Butterworths.
4. Inspection Remarks of Inspectors of Factories and other Safety Authorities.,
5. The Factories Act and Rules of Gujarat, Maharashtra and Tamilnadu
6. Synopsis of the Gujarat Factories (Amendment) Rules, 1995 by K. U. Mistry, Siddharth Prakashan. Ahrnpdahad.
7. Safety and Health in the use of Agrochemical: A guide, ILO, Geneva.
8. Standard specifications of different size Sugar Plants - National Federation of Co-operative Sugar Factories Ltd., New Delhi - 110049.
9. Low - Cost-ways of Improving Working Conditions:- 100 Examples from Asia by K. Kogi, W. Phoon and J.E. Thurman, By ILO
10. Safety and Health in the Construction of Fixed Offshore Installations in the Petroleum Industry, ILO
11. Petroleum Production Handbook (2 Volumes), by Frick, McGrow Hill Book Co.

CHAPTER – 24

Industrial Hygiene and Health

THEME

1. *Industrial Hygiene :*
   - 1.1 *Meaning of Industrial Hygiene (IH).*
   - 1.2 *Differnece between Industrial Hygiene & Occupational Health.*
   - 1.3 *Work co-ordination between industrial hygienist, Safety Officer and Factory Medical Officer for the purpose of Safety.*
   - 1.4 *Occupational Health Hazards*
     - *1.4.1 Introduction & classification of occupational health hazards,*
     - *1.4.2 Adverse Health Effects & Controls.*
     - *1.4.3 Dangerous Properties of chemicals & their Health effects*
   - 1.5 *Routes of Entry & Toxic Effects*
     - *1.5.1 Routes of entry to Human system.*
     - *1.5.2 Toxicity and Relevant Terms*
     - *1.5.3 Types and Degrees of Toxic Effects*
     - *1.5.4 Permissible & threshold limits of Exposure & Dosage.*
     - *1.5.5 Dose response relationship & Bio-chemical action of toxic Substances.*
     - *1.5.6 Recognition & Evaluation of Health Hazards.*
   - 1.6 *Air Sampling*
     - *1.6.1 Purpose & Types of Air Sampling*
     - *1.6.2 Air Sampling Methods*
     - *1.6.3 Sampling Strategies*
     - *1.6.4 Samples Analysis Methods.*
     - *1.6.5 Air Sampling Devices or Instruments.*
   - 1.7 *Types of Monitoring*
     - *1.7.1 Workplace or Area monitoring*
     - *1.7.2 Personal Exposure Monitoring*
     - *1.7.3 Biological Monitoring*
     - *1.7.4 Air Quality & Stack Monitoring*
   - 1.8 *Control Measures :*
     - *1.8.3 Air Pollution Controls*
     - *1.8.4 Personal & Medical Controls.*
     - *1.8.5 Administrative Controls.*
     - *1.8.6 Special Control Measures*
2. *Physiology of Work :*
   - 2.1 *Definition :*
   - 2.2. *Physiology of Respiration*
     - *2.2.1 Cardiac Cycle or Cardio Vascular system*
     - *2.2.2 Muscle Contraction & Muscular work*
     - *2.2.3 Assessment of Workload based on Physiological Reactions*
     - *2.2.4 Criteria for Limits of Manual Lifting & Carrying.*
   - 2.3 *Aerobic (Physical) Work Capacity*
     - *2.3.1 Factors affecting Aerobic Capacity and Work performance.*
     - *2.3.2 Physiological Safe Limit for Continuous work*
   - 2.4 *Assessment of Work Capacity :*
     - *2.4.1 Tests for Physical Fitness*
     - *2.4.2 Fatigue and Rest Allowances.*
     - *2.4.3 Nutrition, Diets, Physical Fitness & their relationship.*
3. *Ergonomics :*
   - *3.1 Introduction to Ergonomics & its Constituents*
   - *3.2 Application of Ergonomics for Safety & Health.*
   - *3.3 Load Carrying :*
     - *3.3.1 Safe Use of Muscle System & Lever System in Load Carrying*
     - *3.3.2 Physiological Problems with load Carrying (Injuries, Fatigue etc.) & their Solutions.*
   - *3.4 Hand Tools and their use.*
     - *3.4.1Design of Tools in relation to Body Postures.*
     - *3.4.2Safety while using Hand tools*
     - *3.4.3 Safety while using Power tools*
     - *3.4.4 Tools boxes, Kits & tool maintenance*
   - *3.5 Work Station Design :*

I INDUSTRIAL HYGIENE :

1.1 Meaning of Industrial Hygiene(IH):

Industrial (Environmental) hygiene is defined by the American Industrial Hygiene Association (AIHA) as that science and art devoted to the anticipation, recognition, evaluation and control of those environmental factors of stresses, arising in or from the workplace, which may cause sickness, impaired health and well-being or significant discomfort and inefficiency among workers or among the citizens of the community.

Thus Industrial Hygiene deals with (1) anticipation ie. identification (2) recognation ie. acceptance (3) evaluation ie. measurement and assessment and (4) control of workplace hazards or environmental stresses (heat, cold, humidity etc) imparing health of the workers or public.

Anticipation includes prior knowledge of possible hazards and their effects on health. It includs all methods of identification of hazards.

Recognation means acceptance of ill-effects of the identified hazards and accepting that environmental stresses endanger life and health accelerate ageing process or causes discomfort, (qualitative assessment) Evaluation means measuring or calculating the degree of hazard (quantitative) by instruments, air sampling and analysis, comparison with standards and taking judgement whether measured or calculated hazard is more than or less than the permissible standard, (quantitative assessment)

Control includes engineering and administrative controls, safe disposal of wastes, medical examination, use of PPE, education, training and supervision.

The scientific approach adopted in applying Industrial Hygiene includes, identifying the extent of toxicity (harmful effects) of chemical, physical and biological agents; identifying the extent of employee exposure through inhalation, skin absorption or ingestion; recommending and implementing process controls that reduce exposure to harmful substances and following safe work practices including use of personal protective equipment to guard against the exposures.

The Health effects are unlikely to occur unless exposure occurs. The science of qualitative and quantitative exposure assessment is applied in determining the extent of exposure. These data, then are used in determining the need for implementing prevention and control measures.

1.2 Difference between Industrial Hygiene & Occupational Health:

Industrial hygiene deals with Control Techniques to reduce or eliminate ill-effects of environmental hazards like chemical, physical, biological and ergonomic hazards on human health. The control techniques are mostly Engineering Control Measures which try to measure, quantify, monitor, control and eliminate (i) Chemical hazards like dust, gas, fumes, acids, solvents etc. and (ii) Physical hazards like temperature, pressure, noise vibration, radiation etc. (iii) Biological hazards like bacteria, virus, fungus, insects, moulds, parasite, algae, protodones, mematotes, mycoplama, cells lines and other micro-organisms or genetically engineered organisms or cells that can cause a disease and aspects of drinking water, cleanliness, waste and sewage disposal, food contamination etc., and (iv) Ergonomic hazards like pain, illness or accidents due to wrong design, awkward position, improper lifting, man-machine (or job) non-alignment etc. Application of engineering and biomechanical principles can eliminate such hazards.

Thus branch of industrial hygiene needs primarily engineering and biomechanical knowledge and expertise. Therefore, it is called "Hygiene Engineering" also.

Occupational health studies the mode, effects and consequence of environmental hazards or stress - chemical, physical, biological and ergonomic - on human health. The techniques are mostly medical .and study (i) Ill-effects or diseases on health, bodily disorder or maladjustment (ii) Medical remedies to remove occupational illness or disease and improve health (iii) Preventive measures to avoid disease and to maintain good health and (iv) Improvement of nutrition and general physical and mental health of the workers.

Industrial hygiene attempts to eliminate or minimise the exposure of environmental or work hazards on human or public health by engineering controls and good housekeeping and keeps the workplace environment clean, pollution free and hygienic while occupational health deals with the effects of exposure that penetrates human health, gives medicines to improve it and by pre-employment and periodical medical examinations, it strives to anticipate (early detection of) occupational disease and tries for continuous health care of the workers.

Occupational Health, also known as Occupational Medicine, aimes at identifying occupational diseases in the early stage. Industrial Hygiene is aimed at identifying and rectifying causes leading to occupational diseases. By the time an occupational disease is identified, it may be too late. Therefore prevention and control of factors leading to occupational illnesses and disease is the best option. Ultimately it increases the life span.

Even if no occupational disease has occurred, the hazards at workplaces reduce the life of exposed people from a few days to few years. Therefore industrial hygiene practice is always useful and most desired to assess and make the workplace safe and to stop decreasing the precious life span.

Distinction with public health:- Occupational health deals with man in relation to his work and working environment inside the workplace, both physically and mentally, whereas public health deals with man inrelation to his environment in society, outside the workplace and where hazards such as air and water pollution, noise, nutrition and infections may affect his health.

1.3 Work co-ordination between Industrial Hygienist, Safety Officer and Factory Medical Officer for the purpose of safety.

The work of Industrial Hygienist, Safety Officer or professional and Occupational Health Specialist or Factory Medical Officer is reciprocal and useful to each other.

Industrial Hygienist can measure and report the hazard level (noise in dBA, gas vapour in ppm, or percentage, light in lux, oxygen level, air velocity, heat stress etc.). He can carry out personal monitoring and report individual exposures. He can assess the need of biological monitoring and report to the Director.

Safety Officer can study this report and suggest appropriate engineering and other controls.

If industrial hygiene -practices are implemented first, there will be less work for the occupational health specialist or doctor and less ill-effects on workers, public and environment.

The work of industrial hygienist is useful to health physician (doctor) in drawing some conclusion and conversely the diagnostic doubt of the physician can be scientifically replied by the hygienist.

Health specialist or Doctor can examine the worker for effect of exposure, can carry out biological monitoring if necessary and suggest necessary medical measures.

Thus work of all the three officers should be coordinated for the purpose of safety.

1.4 Occupational Health Hazards :

1.4.1 Introduction & Classification of Occupational Health Hazards.

In the past, mostly the workers' health was considered in relation to their work and working conditions in industrial places like factories, mines, workshops etc., hence the terms industrial safety and health and industrial hygiene were developed and used. But gradually the concept of health and safety at work was developed and workers' health at any work-place or occupation, not limited to industry, was considered in USA (Occupational Safety and Health Act, 1970) and UK (Health & Safety at Work Act, 1974) and now, therefore, the modern concept is to use the term Occupational Health and Safety covering industrial and non-industrial Occupation health hazards, their effects, controls and preventive measures.

The range of occupational health was also originally limited to occupational diseases or injuries concerned with the work, working condition or the working environment. But with the research in bacteriology at the end of 19th century it was accepted that a disease may arise due to combination of many factors and the definition of occupational health was widened in 1950 at the joint ILO/WHO Committee meeting, to consider promotion, maintenance and protection of health from all factors adverse to health.

Normally workers' health is influenced by non-occupational and occupational factors which can be sub classified as under :

Workers' Health or Work Environment (adversely affected by)

- **Nonoccupational Hazards**
  air, water, food, clothing, housing, personal habits, climate
- **Occupational Hazards**
  - **Environmental**
    - **Chemical**
      - **Inflammable**
        Solvent, Hydrocarbons, Phosphorous, CS_2, Flammable substance
      - **Explosive**
        Dust Solvent, Vapour, Powder, Solid, Substance
      - **Toxic**
        Dust, Fumes, Gas, Vapours, Mist, Poisons, Carcinogens
      - **Corrosive**
        Acid, Alkali, Irritant
      - **Radioactive**
        Atomic energy
    - **Physical**
      Noise, Vibration, Heat, Cold, Pressure, Ventilation airchanges, air velocity, Humidity, Light & Colour, Excessive weight, Overtime work, Physical workload, Radiation
      - **Ionising**
        Alpha, Beta, Gamma, X-rays, Neutrons
      - **Nonionising**
        UV, IR, Microwaves, Laser beams
    - **Instrumental**
      No proper instrument, No control instrument, Faulty instrument, No interlock, No alarm, No trip, No autocontrol, No process correction
    - **Mechanical**
      Unguarded machinery, No fencing, No safety device, No control device, Unsafe machine, equipment, instrument etc.
    - **Electrical**
      No earthing, Short circuit, Faulty design, Current leakage, Open wire, No fuse or cut off device, Static electricity, Nonflameproof fitting or equipment
    - **Biological**
      Bacteria, Virus, Fungi, Parasitic, Plant pest, Micro-organism, Infection, Diseases
    - **Ergonomic**
      Wrong design or layout of machinery, Poor housekeeping, No man-job alignment, Improper design, height or position of controls, Wrong tools, Awkward position
    - **Unclassified**
      Not known but causing health effect
  - **Non-environmental**
    - **Physiological**
      Tender age, Old age, Sex, Illhealth, Sickness, No physical fitness, Nervous strain, Fatigue
    - **Psychological**
      - **Employee's side**
        Wrong attitudes or aptitudes, No motivation or demotivation, Job habit, Smoking, Alcoholism, Emotional upsets, Unskilled, Poor discipline, Absenteeism, Accident proneness, No job security, No job satisfaction, Leadership etc.
      - **Employer's side**
        No education, information or training system for workers

Details and controls of above hazards are explained in respective chapters.

The occupational health is studied by various specialised branches considering different health hazards as under –

Faculty or Approach	Factors or Hazards
Occupational Physiology	Heavy work, heat stress, fatigue etc.
Occupational Psychology	Mental factors like job satisfaction, motivation, attitude, interest etc.
Ergonomics	To make the work suitable to man considering his anatomy, physiology and psychology.
Occupational Pathology or Medicine	Diseases due to exposure to skin, nose and mouth and due to physical factors like noise, vibration, radiation, heat, light etc.
Occupational Hygiene (Engineering)	Measurement and assessment of physical and chemical factors like noise, vibration, light, ventilation, temperature, gas, dust, fume etc., and suggesting engineering and medical controls.
Occupational Safety	Accident prevention considering mechanical, chemical, physical and human factors.
Occupational Psychiatry	Mental deviation or nervous disease due to physical or mental work environment or human relations at work.
Occupational Sociology	Attitudes or behavirous at work, working conditions, management etc.

1.4.2 Adverse Health Effects and Controls:

A short synopsis of above hazards, their adverse effects and control measures are given below.

(1) Heat & Cold

Heat causes burns, exhaustion, stroke, cramps, fatigue, decreased efficiency, pain, discomfort, heal collapse, systemic disorders, skin disorders, psychoneurotic disorders and tendency to cause accident. Acclimatisation to high temperature requires reduction in heart rate and internal body temperature at the expense of increased sweating. Radiant heat (e.g. ovens, furnaces), stagnant heat (e.g. textile mills), and high temperature (e.g. mines, glass furnaces) .create stress and impair health.

The amendment (1995) in Gujarat Factories Rules has prescribed certain limits - Room temperature < 30 °C (80 °F), Air movement > 30 mt/ min. Ventilation openings > 15% of the floor area and in summer when temperature exceeds 35 °C and humidity 50%, air cooling is required. For humidity control dry and wet bulb temperatures are also prescribed u/r ISA.

One UK Standard suggests the following criteria

Environmental Factor	Standard
Air temperature	21 °C
Mean radiant temperature	$\geq$ 21°C
Relative humidity	30-70%
Air movement	30-60 mt / min

Temperature gradient (foot to head)	$\leq 2.5\,^{o}C$

The cold causes chilblains, shivering, frostbite, trench foot, vasoconstriction, hypothermia and erythrocyanosis.

The control measures include (1) sufficient intake of water and salt (2) cotton and protective clothing (3) break in exposure time and more rest intervals (4) engineering controls (5) medical control and (6) acclimatisation of the workers.

For details see Part 8 of Chapter-10.

(2) Air Pressure :

Abnormal air pressure can cause decompression sickness known as 'Bends' (dull throbbing pain in joints or deep in muscles and bones) and 'chokes' (subtemal distress and difficulty in deep inspiration with coughing).

(3) Light & Colour :

Improper and insufficient illumination causes eye strain, eye fatigue, headache, lachrymation, congestion around cornea and miner's nystagmus (chronic effect). Glare or excessive brightness causes visual discomfort and fatigue, tiredness and irritability. There should be sufficient and suitable lighting natural or artificial in all work areas. For details see Chapter 9.

(4) Noise & Vibration :

Noise - too low or too high cause ear strain or pain. Auditory effects are temporary or permanent hearing loss. Non-auditory effects cause nervousness, fatigue, difficulty in conversation, decreased efficiency, annoyance and psychological and systemic effects. The degree of injury depends on intensity and frequency of noise, exposure time (duration) and individual susceptibility.

Vibration of 10 to 500 Hz frequency range as normally found with pneumatic drills, hammers and grinders affects the hands and arms. After exposure of months or years, fingers become sensitive to spasm known as white fingers. Vibrations also produce injuries to joints, elbows and shoulders.

For details see Chapter-12.

Sick or Tight Building Syndrome is a health effect on workers, mostly IT personnel due to heat or cold stress, poor ventilation, poor lighting, or monotonous work in fixed type of environment for a longer period. Sickness is resulted in health effects like indigestion, psychosis (mental fatigue), visual problem, mental feeling of impotency, headache, backache, uneasiness, obesity, acidity etc. Remedial measures include-change in working environment, new and attractive atmosphere, good lighting and ventilation, good house keeping, rotation of persons, recreation facility and staggered working hours instead of continuous eight or more working hours.

(5) Ionising & Non-ionising Radiation :

Electromagnetic radiation consists of varying electric and magnetic fields, operating at right angles to each other. It has both particulate and wavelike aspects. Following table shows the wavelength and frequency for various electromagnetic radiation. Longwaves have low energy, short-waves have high. The higher energy wavelengths (short-waves) are more penetrating i.e. more damaging. X-rays, Gamma rays and cosmic rays have short wavelengths, 10" cm and less, and high frequency, 10'6 c/s and above and cause ionising radiation.

Others i.e. electric waves, radio waves, micro waves, visible light, IR, UV and lasers have longer wavelength and less frequency and cause non-ionising radiation. Lasers are involved in visible light, IR and UV regions of the spectrum given below :

The Electromagnetic Spectrum		
Energy Form	**Frequency c/s**	**Wavelength, cms**
Non-ionising radiation :		
Electric waves	10^{2} to 10^{4}	10^{12} to 10^{6}
Radio waves	10^{4} to 10^{11}	10^{6} to 10^{-1}
Infrared (IR)	10^{11} to 10^{14}	10^{-1} to 10^{-4}
Visible light	10^{15}	7×10^{-5} to 4×10^{-5}
Ultraviolet (UV)	10^{15} to 10^{16}	10^{-5} to 10^{-6}
Ionising radiation :		
X-rays	10^{16} to 10^{18}	10^{-6} to 10^{-9}
Gamma rays	10^{18} to 10^{21}	10^{-10}
Cosmic rays	10^{21} on	10^{-11} on

Types and Limits of Radiation :

(A) Ionising Radiation:

Ionising radiation means electromagnetic or corpuscular radiation capable of producing ions directly or indirectly in its passage through matter. It is not visible by normal eyes. X-rays, Alpha, Beta, Gamma, fast neutrons, thermal neutrons and radionuclides are ionising radiation. Radioactive substance (chemical) must be firmly sealed within metal container to prevent dispersion to active material into surrounding. Radiation hazard means the danger to health arising from exposure to ionising radiation which may be external or internal.

Animal and human studies have shown that exposure to ionizing radiation can cause carcinogenic, teratogenic or mutagenic effects, as well as other sequelae. The NCRP has formulated exposure limits. Some such limits are given below :

Exposure limits given in rems per year are as under:

Whole body exposure Long term accumulation	5 (Age in year – 18) x 5
Testicles, Ovaries and Red bone marrow	5
Skin, Thyroid, Bone	15 to 30
Hands, Feet and Ankles	75
Forearms	30
All other organs	15
Pregnant woman, total during pregnancy,	1 0.5 in gestation period
Population 1 Individual 2 Average	 0.5 wholebody 5 gonads

International Commission on Radiological Protection (ICRP) has prescribed a dose-equivalent limit of 0.5 SV (50 rem) to prevent non-stochastic effects.

Radiation dosimetry in health physics tries to know whether individual radiation exposures are within permissible dose. Various fixed and portable monitors (detectors and survey instruments) are used for radiation exposure measurement. Some fixed monitors are as under:

Type of Detector For type of Radiation.

	Type of Detector	For type of Radiation.
1	Proportional or scintillation counter surface barrier diode	Alpha
2	Geiger-Mueller tube or proportional counter	Beta
3	Ionisation chamber, scintillation counter	X and Gamma
4	Proportional counter, ionsation chamber.	Fast neutrons
5	Proportional counter.	Thermal neutrons

Fixed monitors are either area monitoring instruments or contamination monitoring instruments. Area monitors are used for measurement of air, ganima radiation, neutron radiation and radioactive effluents. The contamination monitoring instruments include hand and shoe monitors, portal monitors, clothing monitors and monitors for contaminated wounds. The dosimeters are to be calibrated for proper use.

Protection Techniques include :

1. Control of exposure time and distance.
2. Shielding.
3. Wearing a film badge to check dose limit.
4. Pre and post employment medical test.
5. Prevention of radiation disease such as skin cancer, ulceration, dermatitis, cataract, damage to bones and blood etc.
6. Use of remote controlled containers.
7. Continuous monitoring and maintaining safe limits by engineering controls and PPE.
8. The sealed container should be leakproof.

Health Physics is a branch of science dealing with improvement of protection against exposure to ionising radiation (IR). The main principles of health physics were defined in 1977 by the ICRP. Three general principles of radiation protection are - (1) justification (2) optimisation and (3) limitation of worker's exposure to radiation.

Medical radiation (x-rays) and nuclear radiation to generate electric power are justified but nuclear weapons for war are not justified.

Optimisation means to keep the exposure as low as achievable

Limitation means to limit the exposure entering a human body by protecting individual or society by devices and observing prescribed safe dose limits.

A record for more than 30 years must be maintained even after completion of job on ionising radiation, of (1) doses absorbed by individual and (2) exposure measurement.

In our present day industry, radiation generating machines and radioactive materials for testing of materials, process control and research have found wide-spread use. X-ray machines are widely used in industry, medicine, commerce and research. Industrial X-ray devices include radiographic and fluoroscopic units used for the determination of defects in materials in packaged food etc. All such uses are potential sources of exposure. The most widely used naturally occurring radio-nuclide is Ra. 226 which is used in medicine and industry. In its use in the medical field, many individuals, besides the patient are potentially exposed to radiation. In industry, the principle uses of radium are for radiography in luminous compound and in making static eliminators. Textile and paper trades, printing, photographic processing and telephone and telegraph companies are the typical industries where the static eliminator may be found. The use of artificially produced radio-nuclides (radio-isotopes) in medical, biological, agricultural fields, and scientific research has been increased. Possible exposure from such radio nuclides is involved with their preparation, handling, application and transportation. Exposures, internal or external, might also arise through contamination of the environment by wastes originating from 'the use of these materials.

Applications of ionising radiation in industry are many. It is used mostly in biological and chemical research, chemical pilot plants and production. It is used for curing, grafting, testing & evaluation, free radicals, cross .linking, polymerisation, disinfection, sterilisation, pasteurisation etc. Productwise it is used in semi-conductors, rubber, adhesives, spices, paints and coatings, membranes, fuels, lubricants, plastic piping, enzymes, cosmetics, pharmaceuticals, medical supplies, foods, flooring, furniture, textile, medical uses, agricultural uses etc.

Biological Effects and Controls : Occasional small dose (e.g. X-ray photograph) does not affect much but small doses for a longer time or more frequent dose or higher dose may cause biological damage to a human body. Radiation energy passes through a body. The energy absorbed in a body is called dose. The time between the exposure and the first symptom of radiation damage is called latent period. The larger the dose or the residence time, the shorter the latent period.

Human body always generates new cells replacing dead or damaged cells. But when ionising radiation causes more damage than the body's repair capacity, biological damage takes place. Injury to individual .is called somatic effect and that being passed into future generations is called genetic effect. The. biological effect is the destruction of reproduction capacity of a cell or carcinogenic effect (cancer) which is difficult to cure.

Biological effect of radiation can be reduced by -

1. Shielding the body portion (especially blood forming tissues and intestine).
2. Shielding by a portion between the source and the human body by a high density material such as lead or concrete wall. Thickness should be increased depending on intensity of radiation.
3. Less dense (less hazardous) radiation (electromagnetic instead of charged particles).
4. Low dose rate or fractionation of the dose and decreasing the dose level.
5. Diminishing O_2 concentration in the tissues.
6. Reducing the exposure time.
7. Increasing the distance from source.
8. Using sealed source of radiation.

9. Monitoring the environmental exposures by various instruments such as film badge, thermoluminescence dosimeters (TLD), pocket dosimeter, Geiger-MuUer tubes (having automatic audible .alarm), ionismg chambers, neutron and proton monitors and keeping them below the permissible threshold limits. Calibration techniques for instruments is most important.
10. Decontamination facilities.
11. Safe disposal of radioactive wastes.

Medical Surveillance : Exposure to radiation workers may not give any clinical signs. Therefore, according to ICRP, the medical surveillance of radiation workers should aim at-

1. To assess the health of the workers.
2. To preserve good general health standards by monitoring the work conditions, exposure levels and the health of the workers and
3. To provide baseline information in case of accidental exposure or occupational disease.

Functions of such medical service include--

1. Scheduling of medicell and radiotoxicological examinations. Pre-employment and during and after (post) employment examinations are necessary.
2. Evaluating the fitness of individual workers for specific tasks.
3. Medical examinations and first-aid after radiation accidents, irradiation or contamination accidents.
4. Keeping of adequate medical records for quite a long time (30 years).
5. Contributing to safety and health training and
6. Helping to solve safety problems in the plant.

Large nuclear installations should have full time and fully equipped medical and health physics services and facilities - including decontamination facilities and ablutions very near the workplace. Small units should obtain part-time facilities.

Personal decontamination facilities include a separate ambulance port, monitoring devices, sink, showers, a disrobing room, clean clothing and pharmaceutical supplies.

Plant medical service should remain in touch with local and other hospitals where irradicated or contaminated persons can be treated.

Radiological Accidents and Controls : When radioactive irradiation or/and contamination is likely to exceed the maximum permissible levels, such overexposure is termed as radiation accidents.

Accidental external irradiation depends on nature of radiation, its distribution in space (exposed area), its penetration in body (dose level) and its duration. In the exposed area irradiation may be of whole-body or partial type. Dose level may be massive, substantial or slight. The biological effect may be irreversible tissue damage, severe but reversible changes or purely temporary disorders. Kind of radiation may be photon irradiation (x or y- rays), particle irradiation by electrons, neutrons and protons or mixed photon and particle irradiation.

Accidental radioactive contamination depends on the nature of the radionuclide (its physical, chemical and radioactive characteristics), local distribution in the body (path of entry through skin, wounds or inhalation), duration (initial and secondary impact following bodily intake) and level of contamination (massive, substantial or slight).

Control Measures necessary are -

1. In case of external irradiation, measurement of exposure in the body and the space, should soon be carried out to decide a course of action.
   Urgent treatment is not essential.
2. In case of radioactive contamination, urgent treatment is essential. Therapy should first be followed instead of measurement of radioactivity and clinical and biological examinations, though they should be followed subsequently to assess the level of contamination.
3. If the whole-body irradiation is more than 100 rem, the person should immediately be transferred to a specialised hospital.
4. Cases of massive whole-body irradiation are difficult to survive, but, they are mostly rare.
5. No immediate treatment is required for slight or partial irradiation. Persons should be observed for some weeks for subsequent development if any.
6. **Therapeutic measures** are as under:
   1. Cleaning and washing of skin and wounds.
   2. Decontamination by surgical excision, but before that a strong chelating agent must be applied locally as soon as possible.
   3. In case of inhalation, emergency medical treatment becomes necessary if the internal contamination exceeds the maximum 3monthly intake or exceeds (500 x Maximum permissible atmospheric contamination per hour). The person should be transferred to a specialised hospital. In serious accidents, the stomach must be washed out and the contaminant at the intestine should be rendered insoluble.
   4. Biological examinations and samplings are necessary. Blood samples must be @ 20 cm^3 by volume and raw i.e. without any additive. The first urine sample and next 24-hr samples are necessary. Samples of the first three stools and one 72-hr after the accident are also necessary.
   5. To check respiratory contamination, the person's handkerchief or nasal samplings by blowing nose into a paper tissue are useful.
   6. Decontamination of substances, objects and persons.

A card containing information of possible contaminants, the time of sampling and any treatment given before the sampling, must be sent alongwith the samples to the radiotoxicological laboratory as quickly as possible.

Decontamination : The ionising radiation cannot be neutralised or interrupted. Therefore rapid decontamination is one of the best safety measures to protect man against possible or actual hazards of direct or indirect radiation. The purpose of decontamination is to reduce its level below the safe level. Following methods of decontamination are used:

1. Mechanical decontamination i.e. removal of radioactive layer by scrubbing, shot blasting, washing by water etc.
2. Physical decontamination i.e. evaporation, dilution, filtration, ultrasonic techniques, or allowing the half-life time if it is in hours or upto 3 days.
3. Chemical decontamination i.e. treating with acid, alkali, chelating compounds, ion-exchange resins etc.
4. Biological decontamination of sewage.
5. Decontamination of water, surface and clothing by selecting appropriate material, e.g. 10% solution of citric acid followed by 0.5% solution of nitric acid to clean stainless steel surface, mineral acids to clean glass and porcelain vessels, replacement of concrete blocks etc. 6. Decontamination of persons by scrubbing the skin with warm water and soap and followed by use of surfactants and absorbents. I to 3% solution of hydrochloric and citric acid are also useful. Use

of organic solvent is inadvisable. Cleaning for more than 10 min. is also not advisable, as further cleaning cannot remove contaminant and may damage the epithelium.

Removal of radionuclides from the human body is much more difficult and needs experienced medical treatment. The choice of a method and reagent depends on the type and character of the contaminant, path of penetration and time elapsed after contamination. Surgery is the best method to decontaminate wound. Complexing reagents (viz. DTPA) are generally effective to decontaminate blood, internal organs and tissues. To decontaminate upper respiratory system, expectorants and vasoconstrictive preparations are prescribed.

See part 15.5.2 of Chapter 18 for radiographic non-destructive testing and Part 5 of Chapter-28 for radiation health effects and statutory controls.

(B) Non-Ionising Radiation :

The main difference between ionising and nonionising radiation is that the former is more hazardous because of its higher frequency range and shorter wavelength comparing with the later which has lower frequency range and longer wavelength. More safety measures - Decontamination, medical and others- are required to prevent and control the ionising radiation and its damage.

Non-ionising Radiation refers to those regions of the electromagnetic spectrum where the energies of the emitted photons are insufficient, under ordinary circumstances, to produce ionisation in the atoms of absorbing molecules. Its lower wave length limit is 100 nm (arbitrary). It includes ultraviolet, visible light, infrared radiation, microwaves, radiowaves, lasers, power frequencies and radar waves.

The Spectrum Phenomenon : The sun's energy is transmitted by electromagnetic waves. If a narrow beam of sunlight is passed through a prism and then projected upon a surface, colourful 'spectrum' is visible from red at one end through orange, yellow, green, blue, and indigo to violet at the other end. If a thermometer is moved slowly from violet to red portion, it shows a rise in temperature. Beyond red (in dark space) it shows a still higher temperature. This dark portion (beyond the red) is called infrared (IR), and the dark portion at the other end (beyond the violet) is called the ultraviolet (UV).

There is no sharp dividing line between IR, visible and UV regions. They differ from each other in frequency, wavelength or energy level. See the table of spectrum in foregoing para. The common factor among them is that all electromagnetic waves travel with the same speed and are originated from moving electric charges.

Physical & Biological Units: The entire electromagnetic spectrum is roughly divided and studied in two parts:

1. The upper region of shorter wavelength is of more concern to physicists and physical scientists who describe radiation in terms of wavelength.

2. The lower region of longer wavelength is of more concern to communication scientists and engineers who describe radiation in terms of frequency.

Both these units are given in the following table

Physical Units of NI Radiation		
Unit	**Symbol**	**Equivalent**
Wavelength		

angstrom	A	10^{-8} cm
centimetre	Cm	1 cm
micrometer	µm	10^{-4} cm
nanometer	Nm	10^{-7} cm
Frequency		
hertz	Hz	1 c/s
kilocycle	Kc	1000 c/s
megacycle	Mc	10^{6} c/s
Gigacycle	Gc	10^{9} c/s

Biological effects of the UV, visible, IR, radio frequency and the extremely low frequency of power transmission, have been studied. Visible light and heat waves can be easily perceived and dark goggles can reduce their intensity to a comfortable level. The UV, IR, microwave and lower frequency radiations cannot be perceived by eyes, but have biological penetration as shown in the following table -

Thermal effects are produced in the skin due to exposure in IR and FM-TV-radio region. Photochemical effects can be produced in the UV and visible regions.

Now, main divisions of non-ionising radiation are explained below in brief.

(1) Infrared (IR) Radiation :

The IR region extends from 750 nm to 0.3 cm wavelength of microwaves.

Exposure to infrared radiation is very common in glass industry and near cupolas and furnaces. Since long-wave infrared radiation is readily absorbed by the surface tissues of the body, it cannot inflict deep injuries in the 'human body. Over exposure produces some discomfort which generally gives adequate warning. However, the eyes may suffer injuries or general discomfort to other parts of the body, there is some evidence that this may result in cataract.

The protective measures against this radiation include the placement of reflective screens of polished aluminium shield near the source. Those screens will direct the .rays away from the personnel into unoccupied space or return them to the heat source. They have been found very effective in many industrial situations. Eyes of the exposed personnel should always be protected, by suitable glasses, from direct radiation arising from areas that given off intense heat, even though the temperature is not necessarily high. Infrared radiation be measured by the black-bulb thermometer and radiometers.

Main industrial IR exposures are from hot furnaces, molten metal or glass and from arc processes. Use of enclosures, shielding, eye protection and safe distance are main safety measures.

(2) Ultraviolet (UV) Radiation :

The UV region is subdivided as Near - 400 to 300 nm. Far - 300 to 200 nm and vacuum -200 to 4 nm.

The effects of ultraviolet radiation are similar to sunburn. Since there is a considerable time gap between exposure and development of injury, deep burns, may be endured without immediate discomfort. This radiation is readily absorbed in human tissue. As a result , superficial injuries are produced chiefly to the skin and eyes. Higher exposure can cause skin or eye damage. The skin effect is called dermatological and the eye effect is called ocular.

Some industrial processes, such as welding, produce considerable amount of ultraviolet radiation. In areas where ultraviolet radiation is quite intense, potentially hazardous chemical contaminants, such as ozone and oxides of nitrogen, are also produced due to action of this radiation on air. In the zone where arc-welding is carried out, very high concentrations of ozone and oxides of nitrogen have been found.

All personnel engaged in welding should invariably wear goggles and face shields. Besides these, the use of gloves, leggings, overalls and boots is an essential necessity for the personnel engaged in welding. Further more, opaque shielding should be used around welding areas to protect other persons. Local exhaust ventilation may also be used as an effective means for the removal of chemical contaminants produced during the arc welding.

Ultraviolet meters can be used for the measurement of .this radiation. It has been suggested that 0.5 microwatt per square centimetre be the permissible limit of ultraviolet radiation for a 7 hours continuous exposure.

The most common exposure to UV radiation is from direct sunlight. Solar irradiation exhibits intense UV radiation but due to the atmosphere (ozone) shielding of the earth (God's gift), we are not exposed to the lethal doses. Long time exposure to hottest sunlight (afternoon) may cause skin cancer. This must be avoided.

Some commercial application of UV radiation are fluorescent lamps, mercury vapour lamps, germicidal lamps, electric arc welding, chemical processing, etched circuit board production and UV lasers.

Wavelengths below 320 nm cause skin reddening and skin-burn (erythemal effect). Solar or UV radiation from artificial sources may cause skin pigmentation (tanning).

Wavelengths between 320 and 230 nm can cause carcinogenic effects.

Main safety measures are shielding of UVR source, use of eye goggles, protective clothing and absorbing or reflecting skin creams.

(3) Visible Light (Energy) :

This portion lies in the range of 400 to 750 nm. The danger of ratinal injury lies between 425 to 450 nm due to peak brightness. Eye response to excessive brightness i.e. partial or full lid closure and shading of the eyes, is a protective human mechanism.

Main sources of visible light are sun, laser beams, arc welding, highly incandescent or hot bodies and artificial light sources such as pulsating light, high-intensity lamps, spotlights, projector bulbs, neon tubes, fluorescent tubes, flash tubes and plasma torch sources.

The visible light is of three types : incident, reflected and transmitted light. Incident light is that light which strikes the work surface. Reflected light is that light which bounces off surfaces and reflected onto work surfaces by walls and ceiling. It is measured to determine glare and shadows. Transmitted light penetrates a transparent or translucent material.

Vision is a photochemical and physiological phenomenon. Exposure to glare can cause fatigue of eyes, iritis and blepharism. But these effects cannot cause pathological changes.

Poor illumination can cause industrial accidents. Direct glare, reflected glare from the work and dark shadows lead to visual fatigue. Better lighting provides safe working environment, better vision and reduces losses in visual performance.

Factors of good lighting are its quantity and quality. The Quantity is the amount of illumination that produces brightness on the task and surroundings. The Quality refers to distribution of brightness in environment and includes the colour of light, its diffusion, direction, degree of glare etc.

See Chapter-9 on Lighting & Colour.

(4) Radio and Microwaves :

Within the broad spectrum of radio frequencies, the microwave .region is between 10 to 3 x 105 MHz (megahertz). This form of radiation is propagated from antennas associated with TV transmitters, FM transmitters and radar transmitters.

Uses of microwave radiation are heating sources like microwave ovens, dryers for food products and plywood, pasteurisation, ceramics, telecommunications like radio and TV and medical applications (diathermy devices). Microwave ovens for heating or cooking food are clean, flexible and instantly controllable. The heating rate is very high and use of any fuel or pollution due to it should be avoided.

Radio or high frequency electrical heaters are used in metalworking plants for hardening cutting tools, gear-teeth and bearing surfaces and for annealing, soldering and brazing. Use in food industry is for sterilising vessels and killing bacteria in foods.

In woodworking plants, high frequency heating is used for bonding plywood, laminating and general gluing. Other uses include moulding plastics, curing and vulcanising rubber, thermosealing and setting twist in textile materials.

Induction heaters are used for annealing, forging, brazing or soldering conductive materials. Induction furnaces are used in foundries to melt metal. Dielectric heaters are used for non-conducting, dielectric materials like rubber, plastics, leather and wood.

The primary effect of microwave energy is thermal. The higher frequency cause lower hazard and vice versa. Frequencies less than 3000 MHz can cause serious damage. At 70 MHz, maximum SAR (specific absorption ratio) in human takes place. Exposure of high intensity and more time can cause localised damage by skin burning, tissue burns, cataracts, adverse effect On reproduction and even death.

The basic safety measures include restricting energy (power density in microwatts/ m2 and frequency) below the safe level, reducing time of exposure, shielding and enclosing microwave source, reorienting antenna Or emitting device, use of PPE and controlling at source.

(5) Power Frequencies:

The main hazards from high voltage lines and equipment (low frequency) are shocks and current. Extremely low frequency (ELF) radiation produces electric field and magnetic field. An external electric field induces electric current in the body.

Protection from ELF is possible by shielding of electric field by any conducting surface. Persons working in high field strength regions (e.g. high voltage lines) should wear electrically conductive clothing. Avoiding entry in such region is also advisable.

ELF magnetic field cannot be shielded. Therefore the only remedy is to keep the magnetic field below safe levels or to restrict entry of personnel into the magnetic fields.

See Chapter-11 on Electrical Safety.

(6) Radar:

Radar means "radio detection and ranging". It is a radio detecting instrument that operates in the radio frequency range from 100 to 105 MHz, echoing in a wavelength range from some meters to millimetres. It consists of a transmitter and receiver, usually operating through a common antenna. Power output varies from a few watts to megawatts.

Hazards & Controls : Main hazards associated with radar are as under :

1. Electrical hazards from high voltage equipment.
2. Fire hazards from flammable gases, vapours, explosives and other materials.
3. Toxic hazards of gas fills in certain waveguides.
4. Thermal effects of electromagnetic radiation.
5. Radioactivity from certain switching tubes.
6. X-rays from high voltage tubes.
7. Material handling hazards in moving portable and fixed equipment.

Control measures include -

1. Standing near or in front of the antenna should be avoided.
2. Radar workers should not look directly into a radar beam from a high energy unit. High energy is more than 0.01 W/cm2
3. Interior of microwave tubes should be seen through a remote device such as a periscope or telescope.
4. Microwave absorber should be provided to contain beam discharge.
5. Persons should take care to have minimum exposure by keeping a safe distance from the beam.
6. Photoflash bulbs should be properly packed to avoid ignition hazard.
7. Pre, current and after employment medical examinations of the radar workers including blood-count and complete eye examination including slit-lamp examination are necessary.

(7) Lasers and Masers :

Laser means "light amplification by stimulated emission of radiation". The original concept was invented by Dr. Charles Townes in 1955. In 1958, he and Dr. Arthur Schawlou presented a paper on how to make an optical maser. Maser means "microwave amplification by stimulated emission of radiation". An optical maser is a laser, therefore, the word laser is mostly used.

Normal light radiates in all directions. Light waves of varying lengths reinforce or cancel each other. Such light is called incoherent. When light waves are made to vibrate in a single plane, made to travel in only one direction and of the wavelength and focused towards a point, a laser beam is obtained. It is called coherent light.

Lasers involve IR, visible and UV regions, concentrate great energy in a point area and can be projected over long distances.

Uses of laser beam are increasing. Typical areas of laser applications are military, microsurgery, medicine, dentistry, material processing, stack emission analysis to detect air pollution, blood analysis, laser drilling & welding, communications, construction, embryology, geodesy, holography, business offices etc.

Hazards and Controls : It is necessary to understand type of laser, its power density, the method of usage and its operational aspects to consider laser hazards and controls. It is not the power (viz. 0.2 watt) but the point source of great brightness which poses hazard. There are two types of hazards - One from the laser itself and the other from equipment.

The solid-state lasers produce high power outputs and can cause skin burns and eye damage if safety rules are not followed. Other hazards are thermal effect, electric shock, ozone effect, high gas pressures in the flash lamp when it is fired (explosion hazard), cryogenic cool burns due to liquid nitrogen and helium, oxygen deficiency if N or He leaks into atmosphere and hazards from viewing, operation and reflections.

The control measures include -

1. Minimisation of ocular exposure to the direct laser beam and specular, mirror type, reflections.
2. Education and training of personnel.
3. Shields to prevent accidental exposures.
4. Specially designed eyewear (a major control).
5. Periodical eye examination.
6. A warning sign to be attached to laser equipment.
7. Laser unit in a separate room.
8. Diffuse or retroreflective card targets should be used for short ranges.
9. Laser beam should not be aimed at flat glass, mirror surfaces or flammable material.
10. Appointment of Laser Safety Officer.

Health hazards depend on the type of material, manufacturing process or work, e.g. poisoning in pesticide industry, chemical exposure in chemical industry, fall and hit accidents in construction industry, finger cutting in power-press industry and dusting in mine industry. Modern trend is to consider biological hazards also. The Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells are useful in this regard. See Chapter-28 for these rules. All these need a specialised occupational health services at workplace. Depending on classified hazards like fire, explosion, toxic and corrosive effects, fully equipped fire fighting team, medical team and trained personnel with special protective equipment are also essential.

Even if an occupational disease has not occurred, the hazardous exposure at workplace can reduce the life span slowly and unknowingly.

1.4.3 Dangerous Properties of Chemicals and their Health Effects :

See Part-7 of Chapter-18 for Material (Property) Hazards, Material Safety Data Sheet (MSDS) and its interpretation. The properties mentioned in MSDS are dangerous properties needing attention for safety. Sch. 9 of MSIHC Rules, 1989, and Sch. 5 u/r 68J(2) of GFR 1963, statutorily require this information. The occupier of a factory has to keep this information ready to show to the workers on request.

Table-4 of Chapter-32 lists such dangerous properties of some chemicals.

Table-9 & 10 of Chapter-32 give health effects of some particulate matters and pollutants. For safe permissible limits of such chemicals to avoid health effects see Tables 10 to 15 of the same Chapter.

For some common chemicals and their health effects and occupational diseases, see Part-4 of this Chapter.

Classification of Air borne Contaminants:

When chemicals are disseminated in air and contaminate it, they are called air-borne contaminants. They are classified according to their physical state as under:

(A) Gases and Vapours :

(1) Gases : Normally formless fluid which occupy the space of enclosure and which can be changed to the liquid or solid state only by the combined effect of increased pressure and temperature. Gases diffuse. The particle size varies from 0.0005 to 0.01 micron.

Examples are chlorine, ammonia, sulphur dioxide, hydrogen sulphide, hydrogen cyanide, carbon monoxide etc. Main pollutants are oxides of carbon, sulphur and nitrogen.

(2) Vapours : The gaseous form of substance which are normally in the solid or liquid state and which can be changed to these states by either increasing the pressure or decreasing the temperature alone. Vapours diffuse. The particle size varies from 0.005 to 0.01 micron.

Examples are vapours of lead oxide, benzene, xylene, trichloroethylene and other solvents.

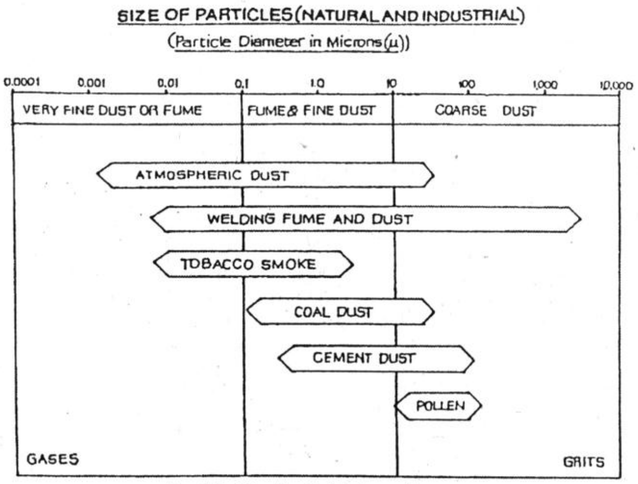
Gases and vapours are also classified as under-

1. Organic solvent vapours e.g. alcohol, acetone, CS_2, CCI_4, benzene, xylene.
2. Pulmonary irritant gases e.g. $C1_2$ NO_2, phosgene.
3. Upper respiratory irritant gases e.g. NH_3, SO_2, formaldehyde, acetic acid.
4. Chemical asphyxiant gases e.g. CO, HCN.
5. Simple asphyxiant gases e.g. N_2, CO_2, methane, its homologues and acetylene.
6. Other inorganic and organic gases e.g. H_2S, arsine and pesticides vapours.

(B) Particulate Matters:

These are solid tiny particles produced by blasting, crushing, drilling, grinding, mixing etc. and suspended in the air. Examples are as under:

(1) **Dusts :** Solid particles generated by handling, crushing, grinding, rapid impact, detonation and decrepitation of organic or inorganic materials such as rocks, ore, metal, coal, wood, grain etc. Dusts do not tend to flocculate except under electrostatic forces. They do not diffuse in air but settle under the influence of gravity. The particle size varies from O.I to 1000 microns. Fly ash from chimneys varies from. 3 to 80 microns.



Particle Size for Solid Aerosols

See Part 4.2.1 for more details.

(2) **Fumes :** Solid particles generated by condensation from the gaseous state, generally after volatilisation from molten metals etc. and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce. The particle size varies from 0.001 to 100 microns. Examples : lead, zinc, or nitrous fumes.

(3) **Mists :** Suspended liquid droplets generated by condensation from the gaseous to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming and atomising. The particle size varies from 50 to 100 microns. Example : sulphuric acid mist.

(4) **Smokes :** Small gas-borne particles resulting from incomplete combustion and consisting predominantly of carbon gaseous material are grouped in this category. The particle size varies from O.I to I micron.

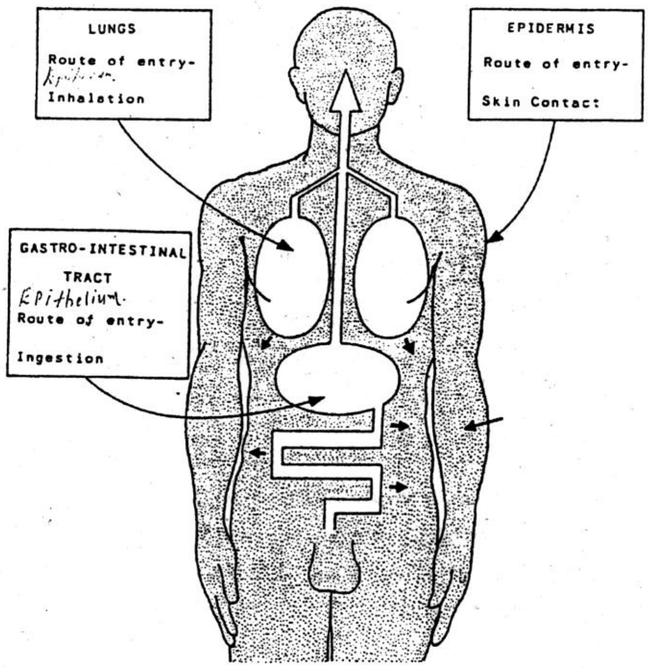
(5) **Smog and Fog :** The air contaminants may be present in the forms of smog and fog which are not usually encountered in an industrial environment. The particle size varies from I to 50 micron.

(6) **Aerosols :** It is a colloidal system m which the dispersion medium is a gas and the dispersed phase is solid or liquid. The term aerosol is applicable till the solids or liquids remain suspended in the gaseous media. The particle size varies from 0.01 to 100 micron. Dust, smoke or mist are examples.

Aerosols affect weather, damage materials and impair health. Atmospheric aerosols like hydrocarbons, lead, arsenic, sulphuric acid etc. may injure human health because of their toxic nature.

1.5 Routes of Entry & Toxic Effects:

1.5.1 Routes of Entry (Avenues) to Human System:



Following are the four main routes of entry of toxic material into human body :

(1) Absorption through skin (Dermal tract) : Skin absorption attains its greatest importance in connection with the organic solvents. The significant quantities of these compounds may enter the body through the skin either as a result of direct accidental contamination or indirectly when the material has been spilled on the clothing. Using industrial solvents for removing grease and dirt from the hands and arms is a source of dermatitis. Some solvents penetrate the intact skin, get into the blood stream and produce ill effects on the blood and throughout the body, e.g. nitrobenzene, aniline, phenol, nicotine, etc.

While manufacturing, handling and spraying pesticides, liquid splashes may enter through skin and cause toxic effects. Vapours of pesticide can enter through nose and solid or liquid pesticide if taken through mouth (unlolowingly, accidentally or suicidal) it can pass through digestive route also. Safety measures are suggested in Part 24 of Chapter-23.

Volatile material like phenol, aniline, nitrobenzene, cresol, tetraethyl lead and many organophosphorous or organo-chlorine pesticides pose greater hazard through skin than through inhalation. Absorption through lessings of the pidemis is more rapid than through the intact skin. Cut skin may absorb quickly. Therefore safety gloves, aprons, face shield, goggles and overalls are always desirable.

(2) Absorption through Gastrointesfinal Tract (GIT) (Ingestion or Digestive Tract) : Use of contaminated and dirty vessels used for eating and drinking is the most common route of ingestion. Accidental swallowing of chemicals is also possible. The detoxification affects the liver exerts when the ingested quantity is small. However, massive dose can lead to fatalities in absence of medical attention.

Contaminated food, drinks, beverages should not be eaten without washing hands and mouth properly. Habit of washing hands and mouth before and after eating, is most desirable. Where it is statutorily required, separate mess-rooms (eating places) are provided (Schedules u/r 102 of the GFR) for this purpose only. Food, drinks, pan-supari, tobacco, lime etc. and smoking are prohibited in workroom.

(3) Absorption through Lungs (Inhalation or Respiratory Tract) : The inhalation of contaminated air is the most important means by which occupational poisons enter into the body. Harmful substances may be suspended in the air in the form of dust, fume, mist or vapour and may be mixed with the respired air in the case of true gases. From 8 - hour working in a day, man may breathe about 10 cubic meters of air. Any poisonous material present in the respired air offers a serious threat.

Among those inhaled foreign matter, some particulate matter is trapped by the mucus which lines the air passages and is subsequently brought out with nasal mucus or phlegm. Other particulate matters are taken up by scavenger cells following which they may enter the blood stream or be deposited in various tissues or organs. True gases will pass directly from the lungs into the blood.

Inhalation is an easy route of entry of the airborne contaminants. Respirable dusts (see Table 15, Chap. 32), gas, vapour, mist dissipated in the air enter the respiratory system through breathing and may reach upto lungs and may transfer from lungs to some sensitive deeper sites also. Lungs damage may cause diseases. See Part 4.2.1 of this Chapter.

Rate of breathing for an average man is as

Activity	**Inhalation (lit/m)**
Resting in bed	6
Sitting	7
Standing	8
Walking (3 km/h)	14
Walking fast (6 km/h)	28
Slow run	43
Maximum exertion	65-100

Thus rate of breathing increases with exertion. Good housekeeping, ventilation, local exhaust ventilation and use of appropriate respirators while handling toxic substances are primary need.

(4) Injection : This fourth route of entry is the direct injection of the material into the bloodstream or the peritoneal cavity of the abdomen or the pleural cavity surrounding the lung. By a needle it can be inserted into the skin, muscle or other part of the body. Mostly this route is used to inject material into laboratory animals. The intravenous injection short-circuits protective mechanisms in the body, which resist the material from entering into blood.

Pre-employment and periodical medical examinations of workers exposed to toxic hazards, are necessary to detect health effects due to such entry of chemicals in human body and to draw inference for engineering and medical safety measures.

1.5.2 Toxicity and Relevant Terms :

Chemicals or airborne contaminants when enter into body through nose, mouth or skin as explained above, make different types of effects depending on their concentration, time of contact of exposure, body resistance etc. To understand this it is useful to understand following definitions first :

Toxic means poisonous or hazardous to health. Toxin or Toxicant or Intoxicant means toxic substance or poison causing harmful effect. It includes carcinogen, mutagen or carc/neo/teratogen. Most of the chemicals are poisons. The right dose differentiates a poison and a remedy.

Toxicity is the ability of a chemical to produce injury once it reaches a susceptible site in or on the body. Toxicometry is the measurement of toxicity i.e. a .system of principles and methods for determination of toxicity and hazards of chemical compounds. The study of nature, properties and effects of chemicals on living systems is termed as Pharmacology. The branch of pharmacology relating to poisons is Toxicology. It is the science of poisons, their effects, antidotes and detection. It is a science that defines limits of safety of chemicals. It is also defined as an interdisciplinary science concerned with the nature and mechanisms of toxic effects due' to chemicals in the working and/or living environment. It can also be defined as the study of action of poisons on the living organism. Industrial toxicology is concerned with the human organism and lies within the broad field of medicine. Toxicology from an occupational health point of view can be used to predict ill effects on workers from exposure to industrial materials. It is then used to design protection levels for workers.

Three main elements of toxicology are (1) Physical or chemical agent capable of producing response (2) Biological system with which the agent may react to produce response and (3) The response must be injurious to the biological system.

Acute toxicity

Adverse effects resulting from a single dose, or exposure to a substance for less than 24 hours.

Asphyxiant

A substance that interferes with the transport of an adequate supply of oxygen to the body by either displacing oxygen from the air or combining with hemoglobin, thereby reducing the blood's ability to transport oxygen.

Carcinogen

A substance that causes cancer.

Ceiling limit

The maximum permissible concentration of a material in the working environment that should never be exceeded for any duration.

Chemical hygiene plan

A written program that outlines procedures, equipment, and work practices that protect employees from the health hazards present in the workplace.

Chronic toxicity

Adverse effects resulting from repeated doses of, or exposures to, a substance by any route for more than three months.

Central Nervous System (CNS)

The central nervous system is the part of the nervous system that consists of the brain and spinal cord.

Combustible liquid

A liquid with a flashpoint at a temperature lower than the boiling point; according to the National Fire Protection Association and the U.S. Department of Transportation, it is a liquid with a flash point of 100 °F (37.8 "C) or higher.

Compatible materials

Substances that do not react together to cause a fire, explosion, violent reaction or lead to the evolution of flammable gases or otherwise lead to injury to people or danger to property.

Compressed gas

A substance in a container with an absolute pressure greater than 276 kilopascals (kPa) or 40 pounds per square inch (psi) at 21 °C, or an absolute pressure greater than 717 kPa (40 psi) at 54 °C.

Corrosive

A substance capable of causing visible destruction of, and/or irreversible changes to living tissue by chemical action at the site of contact (i.e., strong acids, strong bases, dehydrating agents, and oxidizing agents).

Explosive

A substance that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Exposure limits

The concentration of a substance in the workplace to which most workers can be exposed during a normal daily and weekly work schedule without adverse effects.

Flammable

As defined in the FHSA regulations, a substance having a flashpoint above 20 OF (-6.7 OC) and below 100 OF (37.8 OC). An extremely flammable substance is any substance with a flashpoint at or below 20 OF (6.7 OC).

Hepatotoxin

A chemical that can cause liver damage.

Ignitable

A substance capable of bursting into flames; an ignitable substance poses a fire hazard.

Incompatible materials

Substances that can react to cause a fire, explosion, violent reaction or lead to the evolution of flammable gases or otherwise lead to injury to people or danger to property.

Irritant

A substance that causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.

Lacrimation

Excessive production of tears when the eye is exposed to an irritant.

Mutagen

A substance capable of changing genetic material in a cell.

Neurotoxin

A substance that induces an adverse effect the structure and/or function of the central and/ peripheral nervous system.

Radioactive material

A material whose nuclei spontaneously give off nuclear radiation.

Reactivity

The capacity of a substance to combine chemically with other substances.

Reproductive toxicity

Adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring.

Systemic

Affecting many or all body systems or organs; not localized in one spot or area.

Teratogen

A substance which may cause non-heritable genetic mutations or malformations in the developing embryo or fetus when a pregnant female is exposed to the substance.

Toxic substance

In general, as defined in the FHSA regulations, any substance (other than a radioactive substance) that has the capacity to produce personal injury or illness to man through ingestion, inhalation, or absorption through any surface of the body.

1.5.3 Types and Degrees (Rating) of Toxic Effects :

The toxic effect depends on various factor such as -

1. The quality (toxicity & concentration) an(quantity (dose) of the chemicals.

2. The rate and extent to which the chemical i absorbed into the blood-stream, i.e. the exposure time and quantity absorbed.
3. The rate and extent to which the chemical i biologically transformed in the body.
4. The rate and extent to which the chemical or it breakdown products are extracted from the body

Factors of Effective Dosage are :

1. Quantity or concentration of the material.
2. Duration of Exposure.
3. State of dispersion.(dust, fume, gas etc.)
4. Affinity for human tissue.
5. Sensitivity in human tissue or organ.

Types of health effects are local e.g. acid burn to skin or transported through the body to a target organ. The effects are also classified as acute (short duration), subacute (intermediate duration), chronic (long duration), nuisance (dust effect), irritant (causing inflammation),, allergen, corrosive (destroying living tissue) and toxic.

For definitions see previous Part 1.5.2.

Substance is called poison (acute) when it is liable to cause death or serious injury to health if swallowed or inhaled or contacted by skin.

Infectious substance is that toxin which is Viable Micro organism or their toxins which are known or suspected to disease in animals or humans.

Delayed or Chronic Toxic substance is that (2) which, if inhaled or ingested or penetrate skin, may cause delayed or chronic effects, including carcinogenicity.

Ecotoxic substance is that which if released presents or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/ or toxic effects upon biotic system.

Hazards or Toxicity Ratings or Degree of toxicity are given as u (unknown), none (no toxicity), low (slight toxicity), mod (moderate toxicity) or high (Severe toxicity).

These terms indicating whether a material has high, moderate, or slight toxicity hazard or none at all, are obviously somewhat crude, but these still serve as rough guides to the risk involved in exposure to various chemicals until further information can be obtained. See next Part 1.5.4(8).

Range Finding Test : This approach to determining and expressing the degree of toxicity of chemicals used in industry has been developed primarily by H.F. Smith, JR and his collaborators. Its greatest usefulness is in testing new compounds for which no toxicological information exists. The basis of the tests is a comparison of the potency of an unknown compound with that of a more familiar material. This is possible since there are a number of chemicals for which fairly extensive toxicological data are already available. By this technique, a certain amount of valuable information can be obtained within a space of about three weeks.

Types of Exposure : This may be brief or prolonged. Individual susceptibility to exposure depends on age, sex, pregnancy, smoking, alcohol intake and general state of health.

1.5.4 Permissible and Threshold Limits of Exposure and Dosage :

Various limits, values or dosages are assigned to indicate permissible or lethal limit etc. as under :

(1) Permissible Exposure Limits (PELs)

- Set by OSHA, 29 CFR 1910.1000, and 1910.1001 through 1910.1450.
- Specifies the maximum amount or concentration of a chemical to which a worker may be exposed.
- Generally defined in three different ways

1. **Ceiling Limit (C):** the concentration that must not be exceeded at any part of the workday
2. **Short-Term Exposure Limit (STEL):** the maximum concentration to which workers may be exposed for a short period of time (15 minutes)
3. **Time-Weighted Average (TWA):** the average concentration to which workers may be exposed- for a normal, 8-hour workday

Other U.S. Exposure Limits

(2) Threshold Limit Values (TLVs)

- Prepared by ACGIH volunteer scientists
- Denotes the level of exposure that nearly all workers can experience without an unreasonable risk of disease or injury
- An advisory limit; not enforceable by law
- Generally can be defined as ceiling limits, shortterm exposure limits, and/or time-weighted averages
- Usually equivalent to PELs

(3) Excursion Limit - ACGIH

- This limit is applicable to those substances which have no TLV-STELs.
- Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday, and under no circumstances should they exceed 5 times the TLV-TWA, provided that the TLVTWA is not exceeded.

(4) Recommended Exposure Limits (RELs)

- Recommended by NIOSH
- Indicates the concentration of a substance to which a worker can be exposed for up to a 10hour workday during a 40-hour work week without adverse effects, however, sometimes based on technical feasibility
- Based on animal and human studies
- Generally expressed as a ceiling limit, short-term exposure limit, or a time-weighted average
- Often more conservative than PELs and TLVs

(5) Workplace Environmental Exposure Limits (WEELs)

- Developed by AIHA volunteers
- Advisory limits; not enforceable by law
- Typically developed for chemicals that are not widely used or for which little toxicity information is available

(6) Company-Developed Limits

- Developed by company scientists
- Advisory limits; not enforceable by law
- Usually based on only short-term studies of animals
- Generally intended for internal company use and sometimes for the customers

TLV may differ in different countries as shown below :

Substance	TLV in India	TLV in Sweeden
Aniline	2 ppm	1 ppm
Benzene	10 ppm	5 ppm
Oil mist	5 mg/m^3	3 mg/m^3
Trichloroethylene	50 ppm	20 ppm
Vinyl chloride	5 ppm	1 ppm

See Table 15 of Chapter-32 for TLVs and STELs under the Factories Act.

(6) Immediately Dangerous to Life or Health (IDLH):

Concentration immediately dangerous to life or health from which a worker could escape without any escape-impairing symptom or any irreversible health effect (NIOSH/OSHA). It is a concentration at which a person can escape without the use of a respirator within 30 minutes. This is used in selecting type of respirator etc.

(7) Tentative Biological Exposure Limits and Health Based Limits:

In fact the human organism itself may be regarded as a kind of sampling service. A worker's body represents his own individual collector, register and monitor of his personal exposure. To arrive at an accurate evaluation of toxic exposure effect, many additional physiological data are nevertheless required, such as rate of inhalation and quantity df inhaled air, percentage absorption by the skin and (occasionally) by the intestinal tract, retention rate of metabolism and excretion etc. Therefore the biological exposure (biological monitoring) has been gaining increasing attention recently. The tentative biological exposure limits for the most important toxic substances present in industry have been developed.

The most modern approach is to consider the integral exposure resulting from all modes of entry (inhalation, ingestion, skin absorption) including exposure in the living environment. Adopting this approach WHO (World Health Organisation) study group recently published 'health based limits' for occupational exposure to some common heavy metals.

(8) Lethal Dose or Lethal Concentration (LD orLC) :

In experimental toxicology, it is common practice to determine the quantity of poison per unit of body weight of an experimental animal which will have a fatal effect (A scale commonly used is milligrams of poison per kilogram of body weight.)

The commonly used expressions are :

LD_0 Highest concentration that would be tolerated in animals with no (zero) death.

MLD Minimum lethal dose, which cause even one

or LD_{L0}	fatality in a group of test animals.
LD_{50}	Lethal dose for 50 percent, the dose that kills one half of a group of test animals (usually ten or more).
LD_{100}	Lethal dose for 10(kills all of a OTOUD

This dose may also be expressed as lethal concentration(LC) for air borne toxic substances. See Reference No. 21 and 27 (at the end of this Chapter) for such values of different chemicals.

LC_{10},, 500 parts of substance per million parts of air (ppm) indicates 500 ppm concentration that kill 50% of the test animals in a stated length of time. With LC values time-span should be stated because the same concentration produces different effect, when given for different duration, e.g. more time more deaths. For example inl-hmm LCL_0 for chlorine is 430 ppm/ 30M. This means if 430 ppm chlorine is inhaled by a group of men for 30 minutes, at least one will die. ihlrat LC_{50} 293 ppm/IH means 293 ppm chlorine for one hour can kill 50% of rats sample.

Other terms are:

TCL_0 = lowest published toxic concentration.

TD or TDL = toxic dose level.

TDL_0 = lowest published toxic dose.

In Sch. I of MSIHC Rules, capacity to produce major accident hazards, toxicity is classified as under:

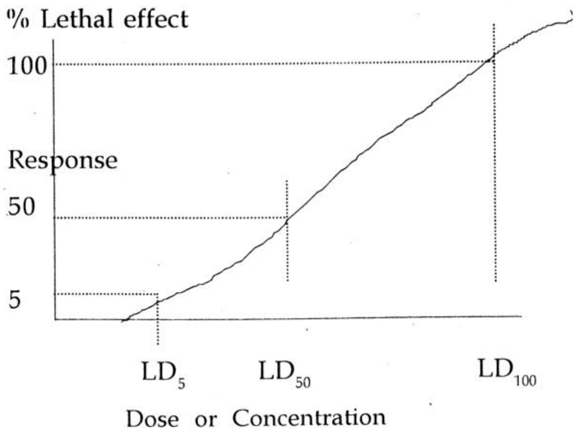
Toxicity	Oral LD_{50} mg/kg	Dermal LD_{50} mg/kg	Inhalation LC_{50} Mg/I
Extremely toxic	< 5	< 40	< 0.5
Highly toxic	5-50	40-200	0.5-2.0
Toxic	> 50-200	> 200-1000	> 2-10

For example, some LD/LC values are shown below:

Name of the chemical	TDL oral-rat LD_{50}	Ihl-rat LC_{50}	Ihl-cat LCL_0	Skn-hmn TCL_0
Calcium cyanide	39 mg/kg	-	-	-
Chlorine	-	293 ppm/1H	138 ppm/1H	-
Ammonia	-	-	-	1000 mg/kg
Diethyl ether	2200 mg/kg	-	-	-

1.5.5 Dose Response Relationship and Biochemical Action of Toxic Substances :

Dose-response relationship is useful to evaluate toxic effect. Normally test animals are subjected to lower to higher doses and their death-rate (percentage) is observed. It can be plotted in a figure



The doses given are expressed in mg per kg of body weight or per lllm2 of skin surface area or per II13 of the respired air of the test animal. The duration (time length) is also noted.

The dose-response relationship can also be expressed as the product of concentration and time (duration) of exposure : C x T = Constant

The CT value can be used mathematically to derive rough approximation of other combinations of concentration of a chemical and time that would produce similar effects. It can be useful in predicting safe limits for airborne contaminants in environment. Safe limits are set so that the combination of concentrations and time duration are below the lowest harmful level.

Interaction between Toxicant and the Body :

The interactions between toxicants and living organism comprise two aspects (1) Toxico-dynamic phase i.e. effect of toxicant on organism and (2) Toxicokinetic phase i.e. effect of organism on toxicant. This latter phase includes two processes, (i) Distribution process and (ii) Metabolic alterations of toxicants i.e. bio-transformation.

Distribution process includes absorption, transport, cumulation and excretion of toxicants and it depends on two factors (i) the physio-chemical properties of the substance concerned and (ii) the structure of the cell as a basic unit of the organism, especially structure and properties of membranes around and inside the cell.

The respiratory tract acts as gas-exchange device having surface up to 100 m2 in deep inspiration and a network of @ 2000 km of capillaries. The tract has upper and lower part. Soluble gases dissolve in the water of mucous membranes of the upper tract. Less soluble gases and vapours react with epithelium producing local damage (e.g. NO,). The absorption rate depends on solubility in blood, ventilation, blood flow and metabolic rate. Soluble compounds are •absorbed and less soluble are excreted from lungs to expired air. Soluble particulates dissolve at the site of deposition and insoluble are removed.

Absorption through GIT i.e. ingestion of toxicants is influenced by physio-chemical properties of the substance, quantity of food, motility, residence time, properties of the epithelium, surface, pH, absorption, bloodflow, hydrotropy and the presence of other substances. In liver the toxicants are metabolised and mostly degraded and detoxicated. Those present in the blood can be excreted into bile and intestines. A part of these excreted intoxicants can be reabsorbed in the GIT.

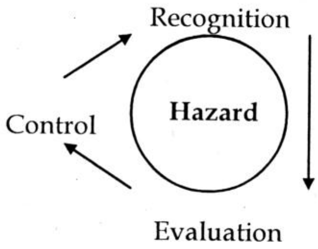
The skin consists of three layers - epidermis, true skin (dermis) and subcutaneous tissue (hypodermis). From the toxicological point of view, the epidermis plays an important role. Absorption through skin can take place (i) through lipid membrane in the epidermis (ii) around hair-roots and (iii) free entry if the barrier is damaged by mechanical trauma, chemical injury or by skin disease.

After absorption the toxic substance will reach the blood, lymph or some other body fluid. Blood is the important transport vehicle. After transport, the toxicants are distributed by uniform distribution in body fluids and deposition in reticulo-endothelial system of organs, in adipose tissues, in bones and in hair and nails.

Lastly excretion process takes place. The same mechanism that is involved in uptake is involved in the elimination of a toxic substance from the cell and body. Elimination depends on the properties of the toxic substance, its concentration and its binding in various compartments.

1.5.6 Recognition and Evaluation of Health Hazards :

Recognition means identification of nature, type and degree of hazard and evaluation means sampling and measurement of the identified hazard by direct reading instrument or laboratory tests and comparing the results with the norms or acceptable levels. Then follow the control measures to reduce the concentration (amount) below the norms for the purpose of safety and satisfaction.



Recognition (identification and exceptance) and evaluation (measurement and assessment) of the health hazards is the main work of an Industrial Hygienist. Then in designing and applying the engineering control, he and the Safety Officer have to contribute. The occupational health physician has to study and detect health effects on workers and to suggest medical measures.

Industrial hygiene approach or application includes -

1. Identification of health hazards and extent of their effects on body.
2. Identification of environment exposures to workers through different routes of entry into the body.
3. Recommendation and implementation of process controls to reduce exposures and following safe work practices including use of PPE.

Recognition requires knowledge of raw materials, storage conditions, process parameters, byproducts and products, waste generation and disposal, types of industrial operations, process flow sheet, check-list, MSDS etc. Then field survey should be carried out to identify potential hazards, worst cases and other health hazards. Then by sensory perception and control measures in use, the hazards should be accepted and measured in priority of their severity.

In evaluating or appraising toxic health effects following factors are important -

1. Nature of substance of exposure i.e. quality of exposure.
2. Quantity or concentration of the material.
3. Duration or length of exposure.
4. State of dispersion (e.g. dust, gas, fume etc.)

5. Intensity or severity of exposure.
6. Personal susceptibility or resistance.
7. Affinity for human tissue.
8. Solubility in human or organs.
9. Sensitivity in human tissue or organs.

There may be wide variations in any of these factors. Environmental survey or study should be carried out to record toxicity of the substance and workers exposure periods. After collecting such sufficient examples, workers weighted exposure to hazard (dust, gas, fume, vapour etc.) can be calculated.

For recognition the Material Safety Data Sheet (MSDS) is most useful to understand the physical, chemical, fire, explosion and health hazard properties of the material, what, how and when can go wrong and some primary first-aid, medical and spill-control measures also. For details see Part 7.2 of Chap. 18.

Hazards to be recognised should be classified. They include physical, chemical, instrumental, mechanical, electrical, biological, ergonomic, physiological and psychological hazards. Further information on recognition is given in Parts 1.4.1 and 1.4.2 of this Chapter. Some visible hazards like poor illumination, ventilation, temperature, noise etc. can be easily recognised by walk-through survey.

Evaluation techniques include measurement of noise, light, temperature, ventilation, heat stress, collection and analysis of air sample, and comparing with safe or legal limits.

For evaluation either air-samples are collected and tested in laboratory or by using direct-reading meters the results are obtained. Recorders can be connected to direct-reading meters to obtain a continuous recording of the meter reading. It can be plotted with time. Peak concentrations are important when the vapour is irritant, highly odorous or if subjective complaint is obtained.

The ultimate aim of the evaluation is to take judgement of the required control measures, after comparing measured values with the acceptable values.

Purpose of evaluation is to know the type of matter, its concentration, energy and length of time during which it reacts with body tissues. Dose-response relationship should be known to evaluate the degree of injury. Hazards of noise, vibration, light, radiation, heat etc. need to be measured to keep within permissible or safe limits.

In addition to MSDS, ACGIH values, statutory information (safe limits and control measures), and INTERNET information can also be available nowadays on health hazards, effects reported or known and a variety of preventive and control measures.

Exposure Assessment

"Having a toxic chemical at a workplace does not necessarily mean that it will cause an occupational disease". The exposure and toxicity together contributes in causing occupational diseases. Exposure assessment is aimed at defining extent of exposure to an occupational toxicant that may, or may not, lead to health hazard.

Qualitative exposure assessment

In qualitative exposure assessment, exposure potential is determined by identifying all exposure sources, determining exposure duration, evaluating effectiveness of the controls provided and ultimately integrating these data to arrive at a conclusion on the extent of exposure. The factors evaluated in exposure assessment are, toxicity of the chemical, properties and volume of the chemical used, duration of the exposure, individual tolerance of potentially exposed person, age and gender of the employee, the effectiveness of the exposure control measures provided, the use and effectiveness of personal protective equipment, general work practices such as rest periods, eating or smoking in the workroom, the presence of visible dust or fumes in the atmosphere.

Pfizer Inc., New York has developed an exposure assessment software titled "WORKBOOK" which integrates the above parameters and provides conclusion on severity of the risk.

Quantitative exposure assessment

In quantitative exposure assessment an employee exposure to a toxicant is quantified and compared with exposure limits to determine the severity of the exposure. Various types of monitoring are applied in conducting quantitative exposure assessment such as (1) Direct and Indirect biological monitoring and (2) Air, noise etc. Area or Personal monitoring.

1.6 Air Sampling :

Basic need of air quality sampling and work environment monitoring and analysis is to find the level of pollution and to work out strategy to reduce it. Need of sampling and monitoring is statutorily suggested by Form no. 37, Rule 12B of the Gujarat Factories Rules. The format calls for identification of airborne contaminants, sampling instruments and methods, number of samples and comparison of measured value with the TWA concentration in 2nd schedule of the Factories Act to assess the working environment and also the number of workers exposed to that. Correct record of such workplace monitoring is essential for good health and good housekeeping.

Need of sampling and monitoring is also inferred from the types, sources and hazards of air pollutants mentioned below. Monitoring is more than air sampling or medical examination of a worker. It includes a series of actions to assess the protection necessary.

1.6.1 Purpose & Types of Air Sampling:

Purpose of sampling are (1) To determine type and concentration of exposure due to health hazards to workers (2) To determine the types and effectiveness of the control measures provided, any change if necessary in them and new control measures to be provided (3) To investigate complaints and (4) For research purposes.

Types of Air Sampling : They are (1) Personal sampling (2) Area sampling (3) Grab sampling and (4) Integrated sampling.

In personal sampling the sampling device is worn by the worker near his breathing zone to evaluate personal or individual exposure to him.

In area sampling the air samples are taken at fixed places in a workroom or confined spaces to evaluate general concentrations of flammable, explosive or toxic material in air for the purpose of isolation or restriction to work or to design the control measures. It includes continuous monitors for leak detection, ventilation failure, equipment malfunction etc.

Short period (instantaneous) sampling is called grab sampling and long-period sampling is called integrated sampling. Grab sampling is used to measure concentration at a particular time (at least two samples within 5 minutes) e.g. peak value of NH_3 or Cl_2 at a particular time. The sample is collected in evacuated flask or plastic bag, sealed and sent to a laboratory where trace analysis is carried out by gas chromatography, IR spectrophotometry etc. Direct reading instruments can also be used for grab sampling. Temperature and pressure should be recorded during sampling. It should not be used for reactive gases.

Integrated air sampling is carried out by direct reading instruments (e.g. gas detector tubes or digital meters) to measure STEL value for 15 minutes and TLV for 8 hr TWA limits. An air-sampling train consisting of air-inlet orifice, collection media (solid or liquid sorbent, filters and passive monitors), air-flow meter, flow-rate control valve and suction pump, is used by qualified and trained personnel. Direct-reading gas and vapour monitors include (1) Colorimetric devices - stain tubes and hand or battery operated pump (2) Colorimetric paper tape samplers (3) Electrical instruments (4) 0 monitors (4) CO monitors and (5) IR analysers.

Types of sampling is also classified as

(1) **Passive or diffusive' air sampling** which involves collection of airborne gases/ vapours through a diffusion barrier onto absorbing medium without the use of air sampling pump and

(2) **Active air sampling** which involves collection of airborne contaminants by means of a forced movement of air by a sampling pump and through appropriate collection medium i.e. filter.

Selection of equipment for air-sampling is important and depends on many factors such as purpose of sampling, type of sampling, type of equipment available, nature of toxicant, environmental conditions, required accuracy and sensitivity, reliability, property of air-contaminant, presence of other chemicals which may mix or interfere, duration of sampling, cost etc.

Sampling Calculations : Calculations for gas and vapour concentrations depend on gas laws that (1) At constant temperature, volume decreases as pressure increases and viceversa i.e. $P_1V_1 = P_2V_2$ (2) At constant pressure, volume is directly 'proportional to the temperature and (3) At constant volume, pressure is directly proportional to the temperature.

Standard temperature and pressure (STP) condition is 0 ^oC and 760 mm of Hg atmospheric pressure, and at this condition 1 gm-mol of an ideal gas occupies 22.4 litres volume. If the temperature is increased to 25 °C (with pressure constant), I gm-mol occupies 24.45 litres.

Concentration is normally expressed in ppm or mg/m^3. Their relationship is given by

Concentration=mass/volume

$$Ppm = \frac{24.45 \times mg/m^3}{\text{molecular wt.}} \quad \text{or } mg/m^3. = \frac{\text{molecular wt} \times ppm}{24.45}$$

Volume Vm (ml) of material (solvent) to be used to generate concentration C (ml) : the following equation is used –

$$Vm = \frac{C \times MW \times 298 \times P \times Vc}{d \times 24.45 \times T \times 760 \times 10^6}$$

where MW = molecular weight of the substance (gm/mol), P = pressure mmmHg, Vc = chamber volume in litres, d = density (gm/ml), T = absolute temperature of apparatus $^oK = ^oC + 273$.

Samples are collected in the areas of (1) Breathing zone of the worker (2) General atmosphere of the room (3) Operation itself.

The factors determining the duration of sampling or the volume of the air to be sampled are (1) Sensitivity of the analytical procedure (2) TLV, STEL etc. (3) The expected air concentrations.

The number of samples to be collected depends on (1) The purpose of sampling (2) The concentration of the contaminant.

A minimum of 3 to 5 samples are necessary.

1.6.2 Air Sampling Methods:

Two basic methods employed to collect the gaseous contaminants are :

1. Use of a gas collector, such as an evacuated flask. The collector is resealed immediately to prevent loss before to the sample is analysed and
2. Passing a known volume of gas or air through an absorbing medium to remove the desired contaminants from the sampled atmosphere. The absorbing medium is chosen according to its efficiency for a particular contaminants.

Field methods require (1) Survey of work environment to collect basic data (2) Sampling principles or strategies to decide location of measurement (nose level of the worker, at source of emission and in general atmosphere of the workroom) (3) Types of samples (4) Minimum and optimum volume of sample (5) Duration and time of sampling and (6) Number of samples.

Then air sample is collected and the contaminant is removed for analysis. Gas detection tables, papers and liquids are used and finally the results are interpreted.

1.6.3 Sampling Strategies :

Factors to be considered while deciding sampling strategy are as under :

1. Collection techniques : The sampling device is attached to the worker who wears it during his presence in the workplace. It can be held at his breathing zone (nose level). For environmental monitoring, it is placed in a fixed location in the work area. For designing engineering control, it should be placed near the source of emission.

2. Place of Sampling : Purpose of sampling should be decided and accordingly the place, e.g. breathing zone, source of emission, work area, confined space, place of highest concentration, garage, tunnel etc. should be decided.

3. Selection of highly exposed worker : A worker who is closest to the source of toxic emission should be selected. Individual differences in work habits can show different levels of exposure at the same place - the same job, or the same material. Their work methods should be noticed. Air movement pattern should be studied. The ventilation booths, air supply inlets, open doors, windows, combustion or heating processes are some factors which can produce higher concentrations away from the source.

4. **Time of Sampling :** When there are wide temperature difference during different seasons (e.g. summer & winter), samples should be taken during all such seasons. When there are more than one shifts, it should be taken in all shifts. For A.C. area, normally the contaminants remains same throughout the year. The time of highest degree of hazard should be selected.

5. **Duration of Sampling :** The volume of air and duration of sample depend on the type of measurement i.e. 8-hour TWA TLV or 15 minutes STEL value and also on the sensitivity of the analytical procedure or direct-reading instrument.

6. **Types of Samples :** They may be instantaneous or spot samples collected within short period of 2 to 10 minutes and continuous samples collected over a long period in different shifts or on different days for the same spot or the same worker.

7. **Minimum Required Volume (MRV) :** If the volume is insufficient, false result is possible. For detection of lower concentration, larger air samples are required. The minimum required volume is given by -

$$MRV = \frac{S \times 22400}{M \times TLV} \times \frac{760}{P} \times \frac{273+t}{273}$$

where MRV = minimum required volume of sample (litres), S = sensitivity of analytical method mg, M = molecular weight of contaminant, TLV in ppm, P = barometric pressure in mm Hg and t = air temp °C.

If t = 25 °C (or near about) and P = 760,

$$MRV = \frac{S \times 24450}{M \times TLV}$$

and if TLV is in mg/m' instead of ppm,

$$MRV = \frac{S \times 1000}{TLV}$$

1. **Number of Samples :** Again depending on purpose, the number of samples can be decided. For TLV or STEL value, several dozen samples may be necessary to have accurate result Amount should be sufficient for laboratory use and decision.
2. **Accuracy and Precision :** They should be maintained for meaningful data, reliability and compliance of the statutory requirement.

1.6.4 Samples Analysis Methods:

They are classified as under:

(1) Chemical Laboratory Analysis: Micro methods have been developed and accepted as reference methods. They need sophisticated laboratory apparatus and qualified and trained personnel. Their reliability depends on many factors like specificity, accuracy, precision, reproducibility, sensitivity, practical confirmation etc. Choice and purity of reagents are important. Analysis is carried out by (1) Approximation (2) Titration and Gravimetric methods (3) Spectro-photometry (4) Visible

Spectrophotometry (5) Nephelometric method and (6) Calibration Curves. Laboratory equipment includes glassware, accessories, refrigerator, sand bath etc.

(2) Instrumental or physical methods are the advanced methods. They have superseded traditional wet chemical methods of environmental estimations. They require regular calibration, skilled operator and more expense. -The methods include (1) Gas Chromatography (2) Liquid Chromatography (3) Spectrosct)py using visible IR or UV or X-rays (4) Polarography (5) X-ray diffraction analysis (6) Neutron activation analysis and (7) General methods like combustible gas indicators, spectrophotometers and flame ionisation detectors. Sensitivity and specificity are important factors for choice and application of the method.

(3) Analytical methods : These are chemical and physical methods used for determination of contaminants in sample.

1. **Colorometric :** The principle of this methods is the development of he colour by a reagent which is indicative of the concentration of the substance to be analysed. Examples of these methods are determination of zinc, lead, mercury etc. by dithizone extraction.

2. **Ion Exchange :** By this technique it is possible to separate elements from one another. Mercury in urine, fluorine in urine and fluoride sample can be separated for further analysis.

3. **Gravimetric Method :** This method depends on the formation of a precipitate or a residue which can be weighed. Example is analysis of dust samples for free silica.

4. **Volumetric Method :** By the use of standard solution for titration. Examples are acid gases which are titrated with an basic reagent.

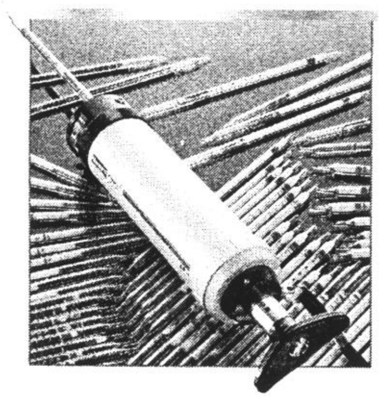
5. **Physical Methods :** The physical methods widely used for the determination of the various contaminants are emission spectroscopy, infrared and ultraviolet spectroscopy, mass spectroscopy, polarography. X-ray diffraction and gas chromatography.

1.6.5 Air Sampling Devices or Instruments :

See fig. 24.1 and 24.2 for different types of air and gas sampling instruments. See Part 8.2.3 of Chapter-25 for- gas monitors.

Various sampling and monitoring instruments are used to measure or/and control toxic hazards of air pollution and other non-chemical hazards also. See Part 12 of Chapter 18.

Sampling devices are of two types. (1) Direct reading devices or instruments (DRI) and (2) Integrated sampling devices.



Direct reading instruments are used for (1) Real time measurement of air borne contaminant (2) identifying presence of acutly hazardous substance (3) locating emission sources (4) evaluating efficiency of operation or its control measure (5) Use as survey instruments.

They include (1) Colour detector tubes for organic or inorganic gases (2) Portable GC for organic vapours and (3) Laser monitors for aerosols and dusts.

Some instruments are mentioned below :

Sampling Instruments : The basic requirements or main parts of any sampling instrument are :

1. **Source of suction,** which may be an electrically or hand-operated pump, an aspirator or squeeze bulb. They are of three types - Low flow. High flow and Dual range.

2. **Absorbing medium -** It should be able to efficiently retain the contaminants to be sampled by adsorption, absorption, chemical reaction or mechanical retention filter or collection media.

   Sorbent tubes, bags, filters, liquid and impingers are used to collect airborne contaminants for analysis. Sorbent tubes (activated charcoal. Silica gel) work on principle of adsorption. They are used for non reactive insoluble gas/vapour and give accurate assessment of TWA exposures. Adsorbed material is desorbed (extracted) and analyzed in laboratory.

   Cyclone device is used to collect and seperate respirable particulate matter. Rapid circulation of air separates perticulates according to size. The grit pot remains in place during sampling.

   Impinger is a glass bubble tube. It contains liquid mediator complete absorption of reactive chemicals like acids and anhydrides

   PVC filters are used for respirable dust' e.g. silica, crystalline.

3. **Flow meter (rotameter)** to indicate and control the rate of suction of air to calculate the amount of air sampled. The flow meter attached to instrument must be calibrated with wet or dry gas meter.

Aircheck Sampler Pump is used to sample gases, dust and particulate matter. Its features are (1) Programmable timer operation (2) Range 1-3500 ml/ min (3) Fault indicator will light if the flow is restricted or battery voltage drops to minimum.

Sampler Pump is useful for specific toxic gases which cannot be monitored through gas detector. It can be used while manual handling of toxic chemical, pumping operation and pump gland/seal leakage etc.

Gas Detector is used to detect all toxic and combustible gases and oxygen content in workroom, manholes of storage tanks, tank cars, confined space, pumping station etc. Its range are 0 to 50 ppm for toxic gas, 0 to 100% for LEL and 0 to 25% for oxygen,. Its operating range are : 0 to 40° C for toxic gas, 18 to 40°C for combustible gas and 0 to 40°C for oxygen. Its humidity range is 10 to 90% RG. Long time extreme humidity reduces the sensor life.

Specific Gas Detectors are also available to measure, record (print) and to give audio-visual alarm when set limit is reached. They give direct reading by digital display. Such instruments are portable but costly. They are available to detect $C1_2$, H_2S, SO_2, CO, phosgene etc. An HS meter operates on electrochemical solarographic cell. They should be properly calibrated and used within their ranges of ppm, LEL, humidity and temperature. Dragger gas detector tubes for such specific gases and sampler pumps are also utilised.

For Toxic Substances : Midget impinger, low volume and high volume air sampler, personal air sampler, electrostatic sampler, hexlet, gravimetric dust sampler, gas detector and doctor tubes. Millipore filterholder and filter papers, phase control microscope, binocular microscope, microscope illuminator, dust counting cells, microscope stage micrometer (2.0 mm x 0.010 mm division), filter/microscope eyepiece, cover glasses for counting chamber, spencer bright line counting chamber, MSA calorimetric carbon monoxide tester, scrubber for use with carbon monoxide tester, MSA combustible gas indicator.

For Medical Investigations : Titmus vision tester, audiometer, diagnostic set, blood pressure instrument, research microscope, heamoglobinometer.

For Physiology Studies : Kofrani Michaelis respirometer, bicycle ergometer. Bailey's sample bottle, Lloyd gas analyser, Haldane - Henderson- Bailey's gas analyser, telemetry system, heart rate monitor, stop watch, metronome, fortine barometer, platform scale weighing machine, treadmill, electronic thermometer, Bennett face mask, Harpenden anthropometer, portable stadiometer, bicondylan vernier callipers ; Godart micro-gas analysis apparatus, vitalor, Wrights peak flow meter, wooden stools with adjustable height.

For Noise Studies: Precision sound level meter with condenser micro phone, battery, wind screen, grip handle etc. Sound and vibration kit consisting of sound level meter, octave filter set, calibrator, wind screen, extension rod, cables and batteries.

For Heat and Ventilation Studies : Air velocity meter, Thermo anemometer. Vane anemometer, thermal kit comprising of dry and wet bulb thermometers and glob thermometers, Assmann Psychrometer (spring operated or motorised), Kata thermometers (125 to 130°F).

For Illumination Studies : Illumination or Lux meter.

For Psychological Studies :. Multi choice reaction time apparatus with a control console with 1/100 Sec, stock and stimulus with 3 colour lights (red, blue and green). Selective reaction timer with electrical stop watch having 1/100-60 sec, scale, flicker fusion control unit, photo electric rotary pursuit and automatic projection techistoscope.

Method of using the instrument should be properly learnt and followed. Zero-setting, probe or other attachment using, calibration, simultaneous use of personal protective equipment (using measuring instrument in highly toxic atmosphere), cleaning, maintenance and repair of equipment etc., should be learnt by practical experience.

1.7 Types of Monitoring:

Monitoring i.e. continuing program of observation, measurement and judgement, of four types is possible - personal, environmental, biological and medical.

1.7.1 Workplace or Area monitoring

Air monitoring is done for the determination of concentration in the workplace area or in the breathing zone of the employee. Air monitoring can be done for

Fig 24.1 Different types of toxic/combustible gas detectors, sensors, personal monitor and gas monitoring system.

Fig 24.2 Oxygen meter, Toxic gas detectors, Explosive meter, Flue gas analyser, Dew point meter & Personal air sampler

8 hours, 15 min. or instantaneous. The results are then compared with exposure indices such as TLV, STEL and Ceiling limits.

The concentration of the contaminants present in the workplace area is determined by the area air monitoring. The purpose of area air monitoring is to identify airborne contamination of the contaminant in worst case situation. Area air monitoring is also used to determine background level of contaminants in a work room. Area air monitoring often is conducted by placing sampling device near contaminant emission areas. Continuous area air monitoring is used to detect fugitive emissions, leaks, ventilation failures, and equipment malfunctions before employee exposure occurs.

Hazards of work environment include all types of hazards affecting work environment and arose due to work itself. Therefore chemical, physical, biological, meteorological factors and hazards of work, working conditions, methods, raw materials, process equipment, process, procedure, waste disposal etc. should be considered here. First, their permissible exposure limits - prescribed by law or standard or reasonably tolerable - should be found and kept as target. Then the actual level (existing limit) of all parameters of the working environment should be measured and compared with the target i.e. permissible level and if the measured level is higher than the permissible, the effects should be continued to bring them down to the permissible level. Form No. 37, Rule 12B, GFR is a statutory format in this regard but as it does not include all work environment (other than airborne contaminants), it should be enlarged to include other work parameters like levels of noise, vibration, radiation illumination, temperature, air changes, ventilation, & waste disposal (pollution parameters) etc.

Here the device is placed at targeted work place or the area to be monitored.

1.7.2. Personal Exposure Monitoring

Refer Part 15.5.2(2) of Chapter-18 for personal monitoring against X-ray for NDT.

The concentration of the contaminants present in the breathing zone of a potentially exposed employee is quantified by personal air monitoring. The purpose of personal air monitoring is to identify individual exposure and to ensure regulatory compliance with exposure indices. Personal air monitoring involves the collection of an air-sample by a sampling device worn by the worker. The sampling device is positioned as close as possible to the breathing zone of the worker so the data collected closely approximates the concentration inhaled.

As the persons are directly affected by the health hazards, 'their personal exposure monitoring is most essential. Environmental monitoring is also carried out to assess the health risks to persons. A filmbadge and shield for the measure and protection of ionising radiation is an example of personal monitoring.

The measurement device (head) or dosimeter is kept in the breathing zone by attaching it to the collar. To monitor noise, the device should be placed close to the ear.

Boron, chromium, cobalt, copper, fluorine, iodine, iron, manganese, nickel, molybdenum, selenium, tin, vanadium and zinc are now generally accepted as being essential to the life. Any deviation in the health changes the value of either of the above mentioned metals in the human systems. The analysis of these metals can provide very early indications of occupational health problems but powerful new analytical techniques are not available to most of the laboratories in the world. Development is needed for simple, economic and reliable test for these estimations.

After personal air monitoring is completed the sampling media is analysed in a laboratory using analytical methods such as Gas Chromatography, Atomic Absorption, High Pressure Liquid Chromatography (HPLC). National Institute for Occupational Safety and Health (NIOSH, USA) and Occupational Safety and Health Administration (OSHA, USA) have developed air sampling methods that provides specific information on sampling media to be used, sampling flow rate to be kept, sample volume to be taken and analytical method to be used.

1.7.3 Biological Monitoring

Biological monitoring is defined as the respective and regular measurement and assessment of agents or their metabolites either in blood, urine, secreta, expired air or combination of these to evaluate exposure and health risk compared to an appropriate reference.

The personal air monitoring provides airborne concentration of a contaminant, not necessarily the absorption of the contaminant by an exposed individual. Biological monitoring has distinct advantages over air measurement, mainly because it is the absorbed chemical, and/or its biomarker, is measured.

Biological Exposure Indices (BEIs) are' analogues to TLV, except for BEIs apply to biological monitoring and TLVs to air monitoring.

Biological or biochemical samples are the blood, urine, faeces, breath (expired air), plasma, body fluid, sweat, tissues, hair, nails, saliva etc. They are analysed to measure any change, deformation or damage due to absorption of a toxic material. Measurement of quantity deposition or effect of lead, mercury, cadmium and fluoride in blood or urine gives evidence of their health effect. By establishing baseline levels, such monitoring indicates need of personal or environmental monitoring and also the need of necessary environmental control or improvement in work method or need of personal protective equipment.

Biological monitoring is not a replacement of any other form of monitoring. It is complementary. Work environment monitoring does not give evaluation of individual's exposure which is given by the biological monitoring.

Analysis of biological samples obtained from exposed workers provides information of body burden of the substance, the amount circulating in the blood or the amount being excreted. Though every tissue and fluid in the body can be analysed, but mostly the urine or blood samples are analysed. Previous exposure of CO and many solvents can be known from the exhaled breath samples. In addition to the air measurement, biological assays and determinants are more reliable indicators (markers) of health risks and strengthen the evidence.

Biological analysis can be performed -

1. for unchanged substance in body fluids and tissues, e.g. Pb, Hg, As, Acetone, MEK, phenol, ' styrene etc. This is called Direct Biological Monitoring.

2. for changed substance i.e. metabolite, e.g. phenol formed in urine due to exposure to benzene, aniline or phenol and Hippuric acid formed in urine diie to exposure to Toluene. This is called Indirect Biological Monitoring.

3. for changed level of enzyme or other biochemical substance present in body fluids or tissues, e.g. depression of cholinesterase activity in red cells due to exposure to organo-phosphorous.

Following tables give some examples.

Indications of Breath, Blood & Urine analysis
Breath analysis may indicate the effect of
Alcohols, aliphatic hydrocarbons, chloro-hydrocarbons, Co, ketones etc.
Blood analysis may indicate the effect of Lead, mercury, CO, zinc, manganese, aluminium, cadmium, methyl bromide etc.
Urine analysis may indicate the effect of Most of the toxic metals, gases and compounds such as mercury, nickel, zinc, cobalt, thallium, vanadium, arisine, stibine, benzene, HCN, HF, HBr; aniline, nitrobenzene, acrylonitrile, fluoride, parathion etc.

Metabolic products as Determinants or Indicators or Markers	
Product in Urine	Indicates presence of
Phenol TTCA Formic acid Thiocyanate Hippuric acid Methylhippuric acids Trichloroacetic acid p-Nitrophenol. 2.5 Hexanedione p-Aminophenol	Phenol, Benzene, Aniline CS_2 Methanol Cyanate, Nitriles Toluene, Styrene, Ethyl benzene Xylene Trichloroethylene Prathion n-Hexane Aniline

BEIs or BELs : The ACGIH of USA publishes biological limits known as Biological Exposure Indices (BEIs) for a limited chemicals. They represent the levels of determinants (i.e. the chemical itself or its metabolite(s), or a biochemical change induced by the chemical) which are most likely to be observed in specimens collected from a worker exposed to chemicals. BEIs apply to 8 hr exposures, 5 days a week. Timing is indicated with BEI. The sample should be collected at the same time, otherwise BEI is not applicable. Some BEIs are reproduced below from the ACGIH booklet (2007).

Adopted Biological Exposure Indices

Substance and Metabolite	Time of Sample	BEI
Acetone in urine	End of shift	50 mg/L
Aniline p-aminophenol in urine	End of shift	50 mg/L creatinine
Benzene t.t. muconic acid in urine S-phenyl mercputrle acid in urine	End of shift End of shift	500 μg/g creatinine 25 μg/g creatinine
Cadmium and Inorganic compounds Cadmium in urine Cadmium in blood	Not critical Not critical	5 μg/g creatinine 5 μg/L.
CO Carboxyhemoglobin in blood	End of shift	3.5% of haemoglobin

CO in end-exhaled air	End of shift	20 ppm
Chlorobenzene 4-chlorocatechol in urine p-chlorophenol in urine	 End of shift End of shift	 100 mg/ g creatinine 20 mg/ g creatinine
Chromium Total chromium in urine Total chromium in urine	 Increase during shift End of work week	 10 µg/L 25 µg/L
Lead In blood	 Not critical	 30 µg/100 ml
Mercury Hg in urine Hg in blood	 Prior to shift End of workweek	 35 µg/g creatinine 15 µg/L
Phenol Phenol in urine	 End of shift	 250 mg/g creatinine
Toluene Hippuric acid in urine O-Cresol in urine T in blood	 End of shift End of shift Prior to last shift of work week	 1.6 g/g creatinine 0.5 mg/L 0.05 mg/L
Xylenes Methylhippuric acid in urine	 End of shift	 1.5 g/g creatinine

These values (markers) - BEIs or BELs - can be developed for those substances only which

1. can appear in biological sample.
2. appear as metabolites.
3. change type or amount of body constituent.
4. change activity of an enzyme or
5. change quantifiable physiological function.

Such values cannot be developed for substances which

1. are body constituents and normal metabolites of the body itself and do not show any change.
2. do not dissolve, are rapidly decomposed or have local effect (e.g. corrosives, irritants).
3. produce allergic effects.
4. produce carcinogenic effects.

Initial studies on animals and later on human volunteers, defined the relationships between exposure, absorption, biotransformation, retention and excretion of exogenous substances. Response (damage) of the organism depends on concentration reached in the sites and the concentration depends on physical, chemical and environmental properties, the mode of impact and the person's own biological factors.

Biological Indicators, Determinants or Markers:

Biological indicators are determined from the biological samples - blood, urine, breath, sweat, faces, hair, nails, body fluid, tissue etc. - and their biological analysis. For correct result time of collection of sample is most important because, different chemicals show their significant effects at different time, e.g. metabolite 'methylhippuric acid' in urine is completed within 16 hr after the end of exposure and therefore its sample should be collected at the end of the shift. Similarly sample for determination of effect of trichloroethylene should be taken at the end of week as its metabolite 'trichloroacetic acid' in urine is metabolised slowly.

Thus after taking biological samples (bioassays) at the correct time after allowing biotransformation (metabolic transformation) biological analysis of these samples is carried out to study the biological indicators, determinants or markers. These indicators are (i) the substance itself i.e. exogenous agent (ii) metabolite formed if any and (iii) the metabolic effect (change) produced.

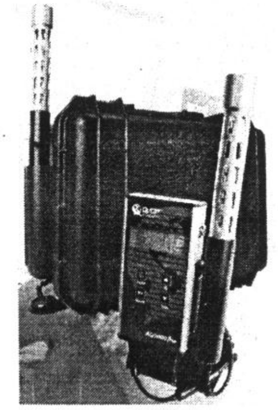
Useful information : Above indicators provide some useful information which cannot otherwise be available, as under :

1. Long-term effect of exposure/absorption.
2. Amount absorbed in body.
3. Routes of absorption.
4. Evaluation of total exposure due to workplace and outside environment.
5. Amount absorbed due to workplace effect, climatic factors, age, sex, genetic characteristics, physical effect, condition of the organs for biotransformation and elimination processes etc.
6. Type and time of risk (exposure) which cannot be proved in any other way.

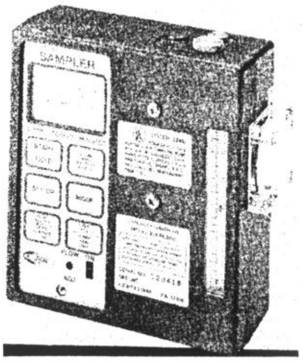
This is the usefulness of biological monitoring.

Medical monitoring means medical examination by the occupational health doctors of the workers exposed to health hazards. Pre, periodical and post medical examination or monitoring gives better judgement. For such facility at workplace and statutory requirement see Part 4.5 of this Chapter.

1.7.4 Air Quality and Stack Monitoring :



Indoor air quality monitor



Air sampler

Section II of the Environment (protection) Act, 1986 prescribes procedure to take samples of air quality. They are to be analyzed by 'environmental laboratories u/s 12 and by government analysts u/s 13. Section 7 puts responsibility on operator of facility to take air samples and to keep them within the prescribed limit. Rule 6 of the Environmental (protection) Rules prescribes procedures for taking samples. Schedules 1,6 and 7 prescribe standards of air quality also in terms of temperature, particulate matter, suspended solids, SOx, NOx, CO and concentration of many gases in the air. See Table 12 and 13 of Chapter 32. Stack height is also prescribed.

Section 22 of the Air (prevention and control of pollution) Act, 1981 requires that the air pollution standards should not be exceeded. Board officers can take samples of air or emission and send them to laboratory for analysis. Board can prescribe stack (chimney) height and air sampling point.

Thus stack monitoring is compulsory to measure SOx, NOx, particulate matter and other gaseous emissions for the compliance of law.

1.8 Control Measures:

1.8.1 Classification of Control Measures:

The control measures can be applied at following three levels.

(1) At Source:

1. Substitution e.g. toluene in place of benzene, silicon carbide in place of silica in grinding stone, or water in place of solvent.
2. Change of process or technology (airless paint spraying).
3. Enclosure of process (cover).
4. Isolation (by space or time).
5. Wet methods (water blasting).
6. Local exhaust ventilation (Capturing at source).
7. Waste disposal (pollution control).
8. Good maintenance.

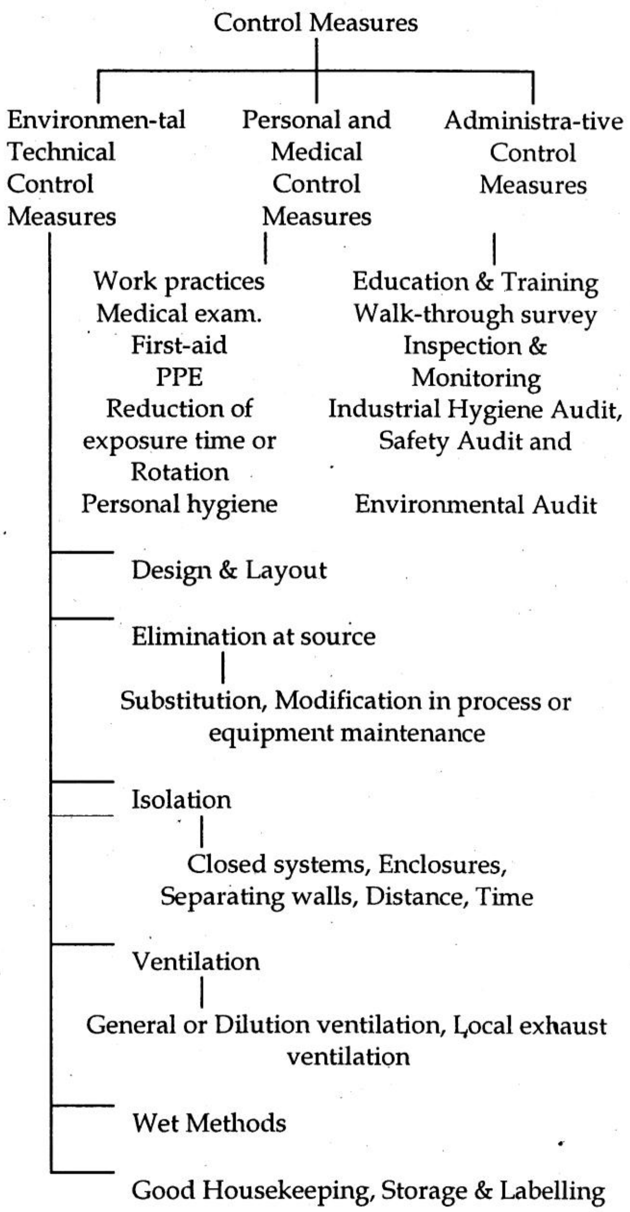
(2) At Airpath:

1. Increasing natural ventilation.
2. Proving exhaust ventilation (fans).
3. Increasing distance between source and the receiver (semi-automatic or remote control).
4. Dilution or Mechanical ventilation (supplied air).
5. Continuous Area monitoring (pre-set alarms).
6. Good housekeeping.
7. Good maintenance.

(3) At Receiver:

1. Personal Hygiene Methods (Washing, bathing, good diet methods, no smoking, no-intoxication etc.).
2. Use of personal protective equipment and good maintenance.
3. Use of protective cream or lotion.
4. Personal monitoring device (Dosimeter).
5. Enclosure of worker (AC cabin).
6. Rotation of worker (Split up of dose).
7. Training and Education.
8. Medical Examination and follow up.

The control measures (technology) can also be classified as under:



1.8.2 Engineering Controls:

In this category are included those procedures which are applied to the working environment rather than to the individual. They are as follows:

1. **Substitution and Modification :** The highly toxic material (carcinogenic, mutagenic or teratogenic) and processes should be replaced by less hazardous materials and processes. Following table gives such examples :

Substance	Substitute
White phosphorous	Phosphorous sesquisulphide
Mercury compounds	Mercury free materials.
Leaded glaze, paint, pigments	Leadless glaze, paint, pigment
Benzene	Cyclohexane or certain ketones
CCl_4	Methyl chloroform, Dichloromethane
Solvents with low B.P. and high V.P.	Solvents with high B.P. and low V.P.

Organic solvents	Detergent and water cleaning solutions
Chlorine	Argon for degassing
Asbestos	Fibreglass
Quartz and	Non-silica aggregates
Sand blasting	Steel or silicon carbide shot
Silica bricks	Magnesite or Aluminium oxide bricks
Sandstone grinding wheel	Synthetic grinding wheel
Broom cleaning	Vacuum cleaning

Precaution required while selecting safer substitute is that it should not bring any new hazard.

Modifications in the process or equipment can reduce the hazard. Reduction in noise, vibration, excessive light and temperature, speed, grinding or mixing speed, mechanical handling instead of manual, use of tongs instead of fingers, sitting posture instead of long-standing etc. help in decreasing the health effects. Following table gives some examples –

Modification	Instead of
Toxic pellet or lump	Powder
Closed charging of toxic material	Open charging of toxic material
Electrical motor	Internal combustion engine
Covered containers	Open containers
Mechanical gauges	Mercury gauges
Mechanical pump seals	Gasket pump seals
Material of the required size	Odd size and then cutting
Copper electric wiring	Aluminium electric wiring
Airless spray	Hand spraying
Low pressure, Low temperature process	High pressure, high temperature process
Water or airjet looms	Ordinary power looms

Use of catalysers (to convert CO into CO_2), silencers, suppressing chemical (urea can suppress generation of NO_2), tank-size reduction, content reduction, dikes to reduce evaporating surface area etc. are also necessary modification/ alterations.

2. **Isolation and Enclosure of a Process :** This has its widest application in the chemical industries where frequently it is possible and practicable to design totally enclosed systems for carrying out the manufacture or processing of chemical compounds. Enclosure may be total or partial. Closed systems, barrier walls, cabins and isolation by distance or time are possible.

3. **Segregation:** This may be accomplished by shifting a potentially dangerous process to a segregated or enclosed area to prevent contamination of adjacent work spaces. In some situations, segregation can be accomplished by locating a process in an open shed or even completely out of doors.

4. **Ventilation :** This is perhaps the most important engineering control measure. Ventilation may be general or local. General ventilation consists in rapid dilution of contaminated air with fresh air usually by fan. Local ventilation usually consists in providing air suction close to the point where potentially harmful dusts, fumes, vapours, mists or gases are generated. Safe collection and disposal of contaminants removed by local exhaust ventilation is necessary. For volatile

chemicals, it is common practice to install a recovery system as part of the ventilating equipment,. See Part 7.3 of Chapter-10 for details.

5. **Wet Process :** The use of water to limit the dispersal of atmospheric contaminants finds its chief application in the control of dust. This procedure is widely used in rock-drilling and useful when sweeping is done in a dusty work room. Water spraying on coal heaps suppresses coal dust.

6. **Neutralisation** or inactivation of chemical compounds is sometimes useful in connection with local exhaust ventilation and in cleaning up contaminated areas. See Chapter-18 also.

7. **House Keeping :** Regular clean up schedules, particularly where dust is a problem are essential in any control programme. See Chapter-8 for details.

8. **Sampling & Monitoring :** It is important to conduct regular appraisals of the working environment by means of dust counts, air sampling and analyses and similar tests, thereby checking the effectiveness of the preventive measures.

1.8.3 Air Pollution Controls :

They make use of -

1. Industrial ventilation systems viz. dilution ventilation, hood, duct, fan etc.
2. Settling chamber and dust collector.
3. Inertial devices viz. cyclone collector, centrifugal collector, multiple cyclones etc.
4. Electrostatic precipitators.
5. Particulate scrubbers viz. cyclone scrubber venturi scrubber, spray chambers etc.
6. Filters viz. filter bed, packed filter, bag filter etc.
7. Absorption devices viz. gas scrubbers, absorption towers.
8. Adsorption devices viz. fixed-bed adsorbers, moving bed adsorbers etc.
9. Combustion devices viz. combustion chamber, flares, incinerators, catalytic afterburners etc.
10. Condensation devices viz. direct contact condensers, surface heat exchangers etc. For the details of such system study Reference No. 5 given at the end of this Chapter.

General safety measures to control air pollution in an industrial area are :

1. Air pollution control technique should be adopted from the design stage.
2. The allowable emission rate should not be exceeded by individual plant.
3. Total load of pollutants in any area should not be exceeded the prescribed limit (community exposure).
4. A continuous air monitoring should be conducted in the locality.
5. Site appraisal Committee (Section 41A of the Factories Act) should consider meteorological and ecological conditions to decide a sitting of a new factory.

Air Pollution Control Systems:

1. The stack height should be sufficient depending upon pollutants, meteorological condition and statutory standards. See Table 12 to 14 of Chapter-32. Heated and unheated emissions should be considered for stack design. Highci stack disperses the pollutants over a wider area thus reducing their concentration.
2. Settling chambers (inertial separators, dynamic separators, wet and multiple cyclones and other devices)
3. Filtration by fibrous mats, aggregate beds filters, paper filters, and fabric filters.

4. Liquid scrubbing by spray chambers, packed towers, plate towers, orifice" scrubbers and mist eliminators.
5. Electrostatic precipitators.
6. Gas solid absorption.
7. Thermal decomposition and
8. Combination systems.

Thermal Incineration is an effective waste disposal methods and is defined as engineered process that use high temperature thermal oxidation to convert waste to a less bulky, less toxic or less noxious material. The flue gases may generally contain CO,, water vapour and inert gases. But depending on the residues being incinerated, it may also contain acidic gases such as halides and their acid oxides of phosphorous, sulphur, nitrogen and entrained salts of metals. Incineration process can be employed to burn solid, liquid or gaseous wastes. Some such processes are given below.

Incineration Process	Temperature Range ^{o}C	Residence Time
Rotary kiln	820 to 1600	Liquids, gases- seconds Solids-hours.
Liquid injunction	650 to 1600	0.1 to 2 seconds
Fluidised bed	450 to 980	Liquids, gases-seconds. Solids-longer.
Multiple heart	Drying zone 320 to 540 Incineration 760 to 980	
Coincineration	150 to 1600	Seconds to hours.
Starved air	480 to 820	0.1 second to hours/
Combustion		

Courtesy : Hitchcok D. - 'Solid Waste Disposal Incineration' Chemical Engineering 86 (II) : 185-194 (1979).

Venturi Scrubber is a simple, high efficiency unit to collect dust or fume by direct contact with water and is useful where the gas to be treated is at elevated temperature or when the contaminant is a difficult or sticky material. A venturi scrubber occupies little space, is easy to maintain and has a further advantage of predictable collection efficiency (dependent upon particle size and density) for a given pressure loss. It may be a low-pressure loss unit (6 to 20 in wg range) or a high pressure loss unit (20 to 60 in wg range).

Refer tables 7 to 15 of Chapter 32 for useful information:

1.8.4 Personal and Medical Controls :

This term is used to describe those procedures which are applied to the employed person (biological sampling, diagnosis and applying remedy). It includes-

1. Preplacement medial examination : Purpose of this examinations is to protect workers with known susceptibility against any potentially harmful exposure, e.g. worker affected by pulmonary tuberculosis should not be placed in exposure of silica and chlorinated hydrocarbon atmosphere.

2. Periodic medical examination : A major purpose is to detect any existing evidence of poisoning at an early stage when corrective measures can be expected to result in complete recovery. Corrections may call for improved industrial hygiene practices for temporary or permanent change of job assignment or both of these.

For medical examinations see Part 4.5 of this Chapter.

3. **Personal Protective Devices :** Protective clothing, masks, and respirators should be properly selected for the purpose for which they are intended and usually worn to prevent injuries. A programme of using, cleaning and replacing worn out parts is highly desirable.
   For details see Chapter-25.

4. **First-aid :** Keep first aider to take charges in the event of an emergency due to poisoning. Give proper first-aid training to workers. For details see Chapter-26.

5. **Laboratory Procedures :** Check blood, urine, stool, lungs, skin etc. to detect onset of symptoms of health effects.

1.8.5 Administrative Controls :

1. **Education & Training :** It is obvious that an informed , educated and trained workman will make less accidents. It is, now, statutory also. As plant and machinery need continuous maintenance, similarly, workmen also need continuous education and training for safe actions, work methods, safe work practices and their role in emergency planning.

2. **Inspection :** Regular walk-through surveys, inspections and monitoring, sampling for physical/chemical health hazards and their analysis and monitoring are always useful to detect the hazards before they worsen. They also suggest the necessary other control measures.

3. **Shift In-charge's Safety Report Book :** It should be a practice that at the end of each shift, before leaving the place, the Shift-in-charge must record all safety points seen and attended or not attended during his shift. The next Shift-incharge, soon after his arrival, must go through this report book and visits those points of the previous shifts and work should be started for unattended points. This cycle should be repeated by all. shifts-in-charge and major point should be reported to the Safety, Hygiene or Medical departments as the case may be. Such practice develops good and continuous safety checks system which is as vital as any other control measure.

4. **Industrial Hygiene, Safety and Environmental Audits :** Refer Chapter-2 for definitions. These are critical, systematic and detailed examination of industrial hygiene, safety and environmental aspects of important health, safety and environmental hazards and effectiveness of their control measures. They go through from policy statement to the final disposal and compliance of statutory provisions (see Chapters 27, 28) and points of previous audit reports and pinpoint what should now be done.

1.8.6 Special Control Measures:

Above mentioned control measures are general measures applicable to most of the industries, but special control measures are required depending on the speciality of the process or material. Such measures may very with the nature of industry. See Chapter-23 for 38 types of different industries and more than 500 control measures.

Biohazards exist due to bacterial, fungal, viral, rickettsial, chlamudial, parasitic agents etc. (see Part 10.9 of Chapter-28) and places where they exist include laboratory, hospitals, agriculture, animal area etc. Their control measures include good housekeeping, personal hygiene, laboratory safety, animal care and handling, biological safety cabinets, use of sterilisation (autoclave) and disinfection and precautions from Acquired Immune Deficiency Syndrome (AIDS) and Legionnaires' disease.

2 PHYSIOLOGY OF WORK:

2.1 Definitions :

Physiology is the science of dealing with functioning of living organisms or their parts. Human physiology is study of the normal functioning of cells, tissues and organs of the human body. The science of physiology is related to Anatomy which is the study of the structure of cells, tissues and organs of the human body. From an anatomical point of view, structure of the body can be classified into systems which have particular functions. To understand the effect of physical and chemical agents on the body, we need to understand the normal functioning of organs or organ systems which these agents target. The systems of human body are skin, respiratory system, cardiovascular system, nervous system, muscles, liver, kidney, gastro intestinal tract (GIT) and ear. The respiratory system, liver and GIT defend the ill-effects of toxic substances.

Physiology of work or Human Physiology may be defined as that branch of knowledge which concerns man as a working being. As a pure science it is a branch of human biology and as an applied science it applies physiological research methods (1) To obtain useful information about physical working conditions (2) To study means to improve them to lighten the worker's task while improving his productivity.

The branch of science dealing with the physiological aspects of man at work is known as Work physiology. It has a basic part, a branch of human biology and an applied part called Industrial Physiology. The object of industrial physiology is to carry out physiological research to know about the working conditions and their improvement methods to make work more comfortable and to increase productivity without unduly straining the worker.

Therefore it studies limits of workload in terms of physiological parameters such as oxygen intake, energy expenditure, heart-rate, sweating rate, oral temperature, muscular work, safe capacity or physical fitness etc., environment parameters and working conditions such as temperature, humidity, working hours, clothing etc., quantity and quality of food, water, nutrition etc. and evolves tests to measure these criteria.

The period during which work continues is known as the work period and the period during which the physiological functions return to the resting level is known as recovery period. The difference between these two levels gives estimate of physiological stress in performing a given task. In order to evaluate total physiological expenditure, one must consider physiological reactions both during the work and during the recovery period. A complete work cycle includes physiological cost of work plus the physiological cost of recovery.

The term ‘Ergonomics’ as used today covers the field of study previously known as applied physiology of work.

Anthropometry is concerned with body build, composition and constitution and the dimensions of the human body in relation to machines, clothing and industrial environment.

Biomechanics studies mechanical forces acting upon anatomical structures during human movement perse or as a result of the interaction between man and the physical environment.

In Part 7.3, Chapter-3 factors affecting work are classified. See their details therein. Physiology of heat regulation is explained in Part 5 of Chapter-10. Heat stress and strain, effects of heat, thermal limits, heat stress indices and their control methods are stated therein.

Factors affecting work performance are given in Part 2.3.1 of this Chapter.

2.2 Physiology of Respiration :

Respiration is aerobic or anaerobic. Aerobic Respiration is the process by which living organisms or their components, take oxygen from the atmosphere to oxidise their food to obtain energy. Anaerobic Respiration is the process by which organisms or their components, obtain energy from chemically combined oxygen when they do no have access to free oxygen. Many organisms can respire anaerobically for a short time only, but certain bacteria depend entirely on anaerobic respiration.

Respiratory Quotient (RQ) is the ratio of the volume of carbon dioxide expired by an organism or tissue to the volume of oxygen consumed by it over the same period.

Respiratory pigment is a substance formed in blood cells or blood plasma that is capable of combining loosely and reversibly with oxygen, e.g. haemoglobin.

2.2.1 Cardiac Cycle or Cardiovascular system (CVS) :

It comprises a closed canalicular network made up of arteries, capillaries, veins and a central pumping organ - the heart. Following a cardiac contraction the blood is distributed to the arteries and then to the capillary areas, returning through the veins back to the heart. The arteries and veins are simple transit vessels whereas the capillaries have an important functional significance since they are involved in the vital exchange of substances between the blood and the inter-cellular spaces, resulting in important modifications in the blood's chemical composition and physical properties.

Cardiac work is the quantity of energy that the heart transmits to the volume of blood to propel it through the vessels. This energy is produced by the oxidation of organic substances such as glucose, glycogen, lactic acid etc., partially converted to mechanical energy during myocardial contraction.

The heart has four chambers - left and right atria and left and right ventricles. There are two separate circulation of blood in these four compartments. The lesser or pulmonary circulation starts at RV and finishes at LA. The greater or systemic circulation starts from LV and finishes at RA. The four cardiac chambers are separated by a system of valves. The two phases in the cardiac cycle are diastole and systole. The cycle occurs around 75 times per minute but it may vary depending on age and physiological condition.

The myocardial fibre (strained muscle cell of special structure) has four basic properties to control cardiac function i.e. rthythmicity, conductivity, irritability and contractility.

The stroke volume has an effect on the arterial wall, the tension of which varies depending on blood pressure. Blood pressure is directly proportional to the volume of blood injected per minute (minute volume Vm) and peripheral resistance.

During effort coronary flow increases considerably whereas myocardial oxygen extraction remains largely the same as at rest. Aortic pressure plays a major role in regulating coronary circulation' - when it increases, it raises the flow and vice versa.

In a normal subject, an average of 90% of the contractile work is used in the propagation of systolic wave, 25-45% of this work is stored in the elastic components, only 10% on average, is not returned and is probably released during the period of isometric relaxation.

Cardiac insufficiency can be defined as the inability of myocardial function to ensure an output that meets the body's requirements. The patient in a state of cardiac insufficiency is not capable to increase his cardiac work to the same degree. The result is a reduction in contractility. The defective heart does not fully utilise the energy obtained from glucose degradation. The result is a reduction in cardiac output. The predominant symptom is dyspnoea, which results from the increase in respiratory work. Due to reduced cardiac output, fatigue, gastrointestinal disorders and renal dysfunction take place. This affects the normal functioning of the various organs.

2.2.2 Muscle contraction & Muscular work :

They are explained as under :

(1) Muscle Contraction

There are about 200 skeletal muscles in the body. Many consist of bundles of muscles, each of which is wrapped - as is the total muscle - in connective tissue in which nerves and blood vessels are embedded. The tissues combine to form tendons that connect the ends of the muscle to bones. The only active action a muscle can do is to contract. It is done by filaments. Elongation is brought about by external forces.

This is a complex phenomenon involving many internal human reactions. Muscle fibres (cells) are controlled by a single motor nerve fibre. This is known as the motor unit. An impulse started in a motor nerve cell (motoneuron) propagates along the nerve fibre and transmitted to the motor endplate where acetyl chlorine is released. This reverses the resting membrane potential. The neuromuscular transmission transduces electrical signals, (nerve impulses) to chemical signals and then back to electrical signals (muscle action potentials). This initiates the mechanical-chemical mechanisms and causes the muscle to react. In the activated muscle, the contractile components (myofibrils), shorten and stretch the elastic components (connective tissue, tendon). When no movement, the contraction is called isometric (static) and when muscle is activated to vary its length, the contraction is called isotonic (dynamic). In the latter case external work can be given by the following equation

Work or energy	=	force x distance
(Nm or Joule, J)	=	(Newton) x (metre)
Power	=	Work per unit time

1 watt (W)
or 1 J/sec = 6.12 kilopond meter per minute
9.81 W = 1 kpm per second
1 HP=736 W=75 kpm/sec - 4500 kpm/min

During work performance a part of mechanical efficiency is dissipated as heat. Thus muscle activation increases heat production which causes perspiration. To prevent overheating during prolonged muscular activity, increased local blood flow and increased heat conductance of skin are essential.

(2) Muscular Work :

(A) Factors affecting Muscular Work :

During muscular work, .physiological functions change from the resting level and heart rate, blood, pressure, cardiac output, respiration, pulmonary ventilation, oxygen uptake, carbon dioxide production, chemical composition of blood and urine, body temperature, rate of perspiration, etc. increase. They come back to resting level when the work stops. The period during which the work continues is known as "Work Cycle" and the period during which the physiological functions return to the resting level is known as "Recovery Period."

By measuring one or more physiological variables during activity, it is possible to determine in what degree the working level differs from the resting level. This gives an estimate of the physiological stress experienced in performing a given task. When the activity ceases, it is possible to follow the return of the same variables to the resting level and to determine the duration of the recovery period, at the end of which the individual has returned to his pre-activity physiological equilibrium. In order to evaluate total physiological expenditure, one must consider physiological reactions, both during the work and during the recovery period. A complete work cycle includes physiological cost of work plus the physiological cost of recovery.

(B) Physiological factors involved in muscular activity are:

1. Fuel or combustion - Nutrients e.g. carbohydrates, fat and protein, their intake and storage.
2. Respiratory quotient - The ratio of carbon dioxide produced to the amount of oxygen consumed.
3. Role of oxygen - Demand, requirement, supply and oxygen extraction.
4. Cardiovascular functions - Cardiac output (stroke volume and heart rate), blood pressure
5. Respiration - Tidal air, pulmonary ventilation (air volume exhaled per minute).
6. Body temperature.

(C) Physiological reactions involved in muscular work are:

1. Intensity of muscular activity - Cardiovascular reactions and aerobic work capacity.
2. Age - Aerobic work capacity, heart rate responses, pulmonary ventilation and blood lactic acid concentration.
3. Sex - As stated in 'Age' above.
4. Body build.
5. Physical fitness or health - Aerobic capacity, heart rate and respiration.
6. Nutrition - Frequency of meals, nature and quality of food and digestive power.
7. Training - Heart rate, blood pressure, stroke volume, respiratory responses, cardiovascular recovery process, aerobic capacity and lactic acid in blood.
8. Temperature and humidity of the work environment - Cardiac output, recovery heart rate, body temperature, work output and posture.
9. Clothing.

Factors responsible for physiological responses to high temperature are:

1. Water and salt content of the body.
2. Individual characteristics - Age, sex, physical fitness, heat acclimatisation and
3. Workload.

Physiological effects of continuous work in Hot Environment are : (1) Cardiovascular stress (2) Heart rate (3) Cardiac cost (4) Blood pressure (5). O_2 uptake and (6) Sweat loss

Physiological effects of repeated work cycles in Hot Environment are : (1) Heart rate (2) Recovery time (3) Cardiac cost and (4) Sweat loss.

Psychic factors affecting muscular (service) functions are attitude and motivation.

Environmental factors that affect are heat, cold, noise, vibration, gas pressure, altitude, air pollution etc.

Nature of work can also affect. It includes intensity, duration, technique, position and rhythm.

All above factors - food and nutritional, physiological, environmental, psychic and nature of work - actuate service functions that deliver fuel and oxygen to the working muscle fibre. This service function capacity transforms food energy (chemically bound) into mechanical energy for muscular work. This ability of the muscle cell to transform energy actuates ability to perform a physical work.

Therefore by paying attention on above factors i.e. giving work according to age and sex, providing rest intervals, reasonable working hours (no overtime), good ventilation, temperature and working conditions, ample drinking water and nutrition, proper clothing, PPE and training etc., good muscular or physical work can be obtained from the workers.

(D) Consequence of Muscular Work :

When muscles work they increase heat production from about 4 kJ/min (resting level) to 200 kJ/min (max.) i.e. about 50 times more. The rate of heat removal, CO, water, waste products etc. must also be increased proportionally. To maintain physical and chemical equilibrium of the cells, a tremendous increase in the exchange of molecules between intra and extra cellular fluid is required. Normal pulse rate 60-72 beats/min can rise upto 220 beats/min, normal oxygen consumption rate 0.2 to 3 lit/min can go upto 4 lit/min and corresponding energy level rises from I Kcal/min to @ 20 Kcal/min. The energy expenditure, core temperature, sweat rate, skin galvanic resistance, heart stroke volume and pulmonary ventilation also increase.

To restore the energy content of the body, working at maximum capacity upto 4 times, more food must be digested, than when the individual is at rest. Moreover, during physical work, many of the hormone producing glands are involved in the regulation of metabolic and circulatory functions of the body.

The energy expended by muscles during work comes from food intake. There are two sources of this energy supply, one is aerobic i.e. direct oxygen intake from air to oxidised food to get energy and the other anaerobic i.e. consuming chemically combined oxygen in the body.

During sever muscular exercise, oxygen demand goes up and up and a stage comes when the body cannot maintain demand and supply. Metabolites like lactic and pyrovic acid get accumulated and the person gets exhausted or feels fatigue. Such physical fatigue, static or dynamic should be removed daily by regular light exercises (Yogasan) and deep breathing in a fresh cool air (in early morning").

2.2.3 Assessment of Workload based on Physiological Reactions:

Hard, heavy work or heat stress imposes excessive physiological strain on the cardiovascular and vasomotor systems. Continuous work is often impossible under such conditions.

Heat produced by the body and the environmental heat together determine the total heat load. Therefore, if work is to be performed under hot environment, the workload category of each job should be established and the heat exposure limit pertinent to the work load should be evaluated against the applicable standard to protect the worker from excessive heat exposure. A workload classification is as follows :

1	Light	Upto 200 Kcal/ hr or 800 Btu/ hr. e.g. sitting or standing to control machines, performing light hard work.
2	Moderate work	200-350 Kcal/ hr. or 800 – 1400 Btu/ hr
3	Heavy work	350-500 Kcal/hr. or 1400-2000 Btu/hr. e.g. pick and shovel work.

A classification applicable to an average Indian worker having 50 kg. body weight is as under :

Variable (Man)	**Physiological Workload (Job)**			
	Light	**Moderate**	**Heavy**	**Very Heavy**
O_2 uptake (lit / min)	0.25 – 0.50	0.50- 0.80	0.80 – 1.00	1.0-1.25
Energy expenditure (Kcal/ min)	1.25 – 2.5	2.5 – 4.0	4.0 – 5.0	5.0 -6.3
Heart Rate (beats / min)	Upto 100	100-125	125-150	150-175

The functions of different human systems are modified according to the physiological demand for the job. The severity of the job can be evaluated b) studying various physiological parameters (reactions) during work. Such parameters are : (1) Oxygen uptake (2) Energy expenditure (3) Heart rate (4) Oral/rectal temperature and (5) Sweating rate.

A proposed classification applicable to Indian workers is as under –

Classification of Jobs (Physiological Load

Physiological Variable (Reactions)	**Very Light**	**Light**	**Moderate Heavy**	**Heavy**	**Very Heavy**	**Extremely Heavy**
O2 uptake (lit / min)	< 0.35	0.35-0.70	0.70-1.05	1.05-1.40	1.40-1.75	> 1.75
Energy expenditure (Kcal/min)	< 1.75	1.75-3.50	3.50-5.25	5.25-7.00	7.00-8.75	> 8.75
Heart rate (beats / min)	75-100	0.75-100	100-125	125-150	150-175	> 175
Sweating rate (ml/hr)	-	-	180-360	360-540	540-720	> 720
Oral Temp ^oC	-	-	37.25-37.50	37.50-37.75	37.75-38.00	> 38.00

Evaluation of workload from above physiological reactions (variables) 0, uptake etc. is in extensive use. Work intensity can be evaluated by measuring pulse rate and blood pressure. Pulse rate measurement is the direct and the simplest method.

Permissible heat exposure limits (TLV) for above workload classification is as under :

Work - Rest Regimen	**Work Load ^oC WBGT**		
	Light	**Moderate**	**Heavy**
Continuous work	30.0	26.7	25.0
75% work, 25% rest, each hour	30.6	28.0	25.4
50% work, 50% rest, each hour	31.4	29.4	27.9

25% work, 75% rest each hour	32.2	31.1	30.1

The ranking of the job may be performed either by measuring the worker's metabolic rate while performing his job or by estimating his metabolic rate with the use of following table.

Assessment of Workload

Average values of metabolic rate during different activities.				
A.	Body position and movement Sitting Standing Walking Walking up hill			Kcal/min 0.3 0.6 2.0-3.0 add 0.8 per meter rise
B.	Type of work		Average Kcal/ min	Range Kcal/min
	Hand work	Light Heavy	0.4 0.9	0.2-1.2
	Work with one arm	Light Heavy	1.0 1.7	0.7-2.5
	Work with both arms	Light Heavy	1.5 2.5	1.0-3.5
	Work with body	Light Moderate Heavy Very heavy	3.5 5.0 7.0 9.0	2.5-15.0

2.2.4 Criteria for Limits of Manual Lifting and Carrying:

(1) Statutory Limits of Lifting: -

See Part 2.1 of Chapter 15.

(2) Criteria for Fixing Limits of Lifting :

In tables of maximum permissible load limits as stated above, three criteria are considered (1) Male or Female as their lifting capability differs at the same age (2) Age as physical muscle strength varies from child to an adult person and (3) Safe load limit which should not cause any injury or back pain.

But other criteria are also considered by researchers in developing some formulae. They are as under

1. Horizontal hand location in front of the midpoint between the ankles at the origin of lift
2. Vertical location at the origin of lift.
3. Vertical travel distance between the origin and the destination of lift.
4. Average and maximum sustainable frequency of lift.
5. Load is lifted by two hands directly in front of the body and no twisting during lifting.
6. The load width is moderate (30 inch or less)
7. Working posture is not restricted.
8. Good couplings (grasp) are applied eg. hand with handle, shoes with floor.
9. Physical environment is favorable.

10. Other work or activity is minimum.
11. Person is physically fit and accustomed to labour.
12. Lift height - floor level to shoulder height and shoulder height to arm reach.
13. Lift frequency - 1 lift or more lifts during seconds, minutes or hour.
14. Lowering frequency - as above.
15. Push force frequency or pull force frequency.
16. Carrying frequency.

Thus material handling process (lifting, lowering, pushing, pulling) is influenced by many criteria, preconditions, assumptions and approaches that need simplification and further evaluation. Therefore simple load tables of excessive weights are preferred.

2.3 Aerobic (Physical) Work Capacity

The evaluation of a worker is made from his physical work capacity i.e. his maximum 0, intake or aerobic capacity, other physiological functions under classified workloads and his tolerance limit to work in hot environment.

The physical work capacity of an individual is measured by the physiological work capacity. This is a measure of his physical fitness and estimated in terms of his maximum oxygen uptake capacity. The upper level of physiological work capacity of an individual depends on his capacity to utilise the inhaled oxygen to its maximum possible limit. Beyond this, any additional work has to be carried out only on oxygen debt. Thus, there is an upper limit of oxygen uptake, being a measure of his maximal aerobic power and the best index to judge one's total physical fitness. This is important for many practical purposes such as selection of right jobs, disability evaluation, rehabilitation of disabled and diseased workers. It is practised in all developed countries.

2.3.1 Factors affecting Aerobic Capacity & Work Performance:

Oxygen intake and oxygen debt are the limiting factors in physical exertion. Factors determining the rate of 0, intake i.e. the efficient supply of 0, to the active tissues are -

1. Ventilation of the lungs.
2. O_2 carrying capacity of the blood.
3. Unloading of O_2 at the tissues, and
4. Minute volume of the heart.

Physical fitness is not a static condition. It varies with age, body dimensions, general health and nutritional state (diet) of the worker. Due to illness or other reason, he may lose his fitness for some time and may regain after some time. A worker doing light work may adjust himself to a low level of physical fitness and vice versa, but a change from light to heavy job necessitates a period of training and adjustment and calls for extra strain on the worker.

Normally female workers can be expected to show 70% aerobic power of males of the same age. Ageing effect decreases heart rate from an average of @ 200 to @ 165 beats/min between the age from 25 to 55 years in both males and females alongwith decrease in functional capacity of other organs.

Maximum aerobic power is determined by measuring the maximum oxygen uptake during dynamic muscular exercise. This can be done in two ways. In the direct method, muscular exercises are performed with increasing intensity until a work rate is established above which there is no further increases in oxygen uptake. In the indirect method, a linear relationship is established between the heart rate and oxygen uptake when the metabolic rate, circulation and respiration have reached a steady state at sub-maximal work rate and the curve is then extrapolated to the maximum heart rate.

2.3.2 Physiological Safe Limit for Continuous Work:

It is obvious that no man should be required to work continuously at his maximum capacity. For safe and efficient work of various systems of the body, a 'safety margin' should be established for 'upper safe limit' or 'acceptable workload' for continuous work.

Besides the knowledge of maximum aerobic power (maximum work capacity) of individual workers, it is essential to know the work limit for sustained physical work for job placement and efficient functioning of the workers in the day to day work. In some work situation the workloads in some tasks are so heavy that the workers are put to undue physiological strain and consequently result in fatigue. Researches in our countries and abroad have suggested that the upper safe limit for continuous work should be fixed around 40 percent of individual's maximum work capacity if physiological fatigue is to be avoided in day's work. Peak loads, even for 20% time of a working day should be reduced by mechanisation to make the heavy job a light one.

This upper safe limit represents the level of physical activity that one can perform in 8 hrs a day in physiologically steady condition without any fatigue or discomfort. Working further in fatigued condition decreases productivity and tends to accidents. Therefore it is essential to reduce stress, strain and fatigue in man.

2.4 Assessment of Work Capacity:

2.4.1 Tests for Physical Fitness :

The test exercises are carried out by ergometers, stepping tests, treadmills, bycycle or running. As a precautionary measure, the person should be medically examined prior to testing and also after maximal testing.

(1) Physiological Test (Step Test) :

The step test was developed in the Harvard Fatigue Laboratory, USA to evaluate the physical fitness of an individual. It is modified for Indian workers and described below :

While carrying out the test, the person has to step up and down on a stool 45 cm. high at the rate of 30 complete steps per minute for a maximum period of 5 minutes or earlier in case of difficulty. The rate of stepping is regulated by a metronome. Immediately after the exercise is over, the subject is seated and his pulse is counted during the period 1 min to ½ min after exercise.

The fitness score is computed as follows :

$$\text{Score} = \frac{\text{Duration of stepping seconds x 100}}{\text{5.5 x (half min recovery pulse count recorded)}}$$

Grading of scores is :

Below	50	-	Poor
	50-65	-	Low average
	65-80	-	High average
	80-90	-	Good

Above	90	-	Excellent

The test score which is computed from the pulse count taken during recovery after exercise is a measure of the individual's cardiovascular efficiency and can be made use of in grading men for their capacity for physical work in general and in hot environments in particular.

(2) Pulmonary function test:

This test is the simplest test in which an ergometer is used to measure exhaled air volume and by comparing it with standard average values, the physical fitness or any disorder is judged.

Other exercise tests are also used to determine physiological load and functional capacities of the cardio respiratory system. In abnormalities e.g. an electrical activity of the heart, cardiovascular disease or improvement after illness or injury.

In young adults 170 beats/min has been widely used as a level at which the intensity of work indicates physical working capacity.

2.4.2 Fatigue and Rest Allowances :

Physiological fatigue is characterised by the gradual decrement of work performance effected by various factors viz. physical, physiological, psychological and wrong working posture. It is manifested by gradual increase in physiological strain as the work of the day progresses.

During work in a hot environment, the body gains heat due to work and external environment. These two factors put a lot of thermal stress on human beings. A continuous work in such environment may lead to exhaustion, if sufficient cooling of the body is not possible. This also leads to lower efficiency and reduced productivity. Under the circumstances a rest interval or pause is essential for the workers to recover from exhaustion as well as to increase efficiency and productivity. Frequent rest pauses reduce fatigue better than a few long breaks.

Rest Allowance in Energetic Work :

Following formula gives percentage rest time Tr as

$$Tr = \frac{Mmax - M}{Mr - M} \times 100$$

where Mmax is the upper limit of the metabolic cost for sustained work, M the metabolic cost of the job (task) and Mr the resting (sitting) metabolism.

$$Tr = \frac{400\text{-}500}{100\text{-}500} \times 100 = \frac{-100}{-400} \times 100 = 25\%$$

This means, rest intervals should have 20% time i.e. 20% x 8 hr = 0.20 x 8 x 60 = 96 min. This can be divided in 3 pauses of 32 min or 4 pauses of 24 min in an 8 hr shift, or 20% per hour i.e., 12 min per each working hour. .

Combination of heavy and light work provide indirect rest. Walking to give or take material, counting for some time, writing record or sharpening tools etc. are examples of light work changes.

According to a German Physiologist (Lehmann), 200 Kcal/hr represents the upper permissible limit, and about 250 'work' Kcal per hour or 4 work Kcal per min. +1 Kcal for resting metabolism represent upper limits for more sustained work. Based on these figures, Spitzer (one of Lehmann's co-workers) has arrived at the following formula to calculate rest allowance for workers engaged in energetic heavy work.

$$\text{Rest Allowance percent} = \frac{(\text{Kcal/min} - 1)}{4} \times 100$$

The above formula may, however, not be applicable to Indians having lower body weights and low physical fitness standard. In their case 3 'work' Kcal per min will represent the upper limit for sustained work. The above formula may accordingly be modified to work out the rest allowances for Indian workers engaged in manual work. -

Above formula represents a method to calculate rest allowance percentage time in total working time. Another method to determine rest pause is from heart beats and is given in the following table -

Rest Allowances at Different Heart Rates

Heart Rate (avg. beats/ min	Energy Expenditure Kcal/min	Rest Allowance (% of working time)	Fraction in 8 hrs working minutes		
			Work	Rest	Total
110	4.3	-	480	-	480
115	4.9	15	420	60	480
120	5.4	30	370	110	480
130	6.3	65	290	190	480
140	7.3	100	240	240	480
150	8.3	136	205	275	480
160	9.2	170	180	300	480
170	10.2	200	160	320	480
180	11.2	235	145	335	480

After working out the time of rest pauses it should be decided that how it should be given to minimise the fatigue.

Reducing Stress and Fatigue :

The decrease in the stress upon the workers and consequently the higher efficiency and morale in the plant may be achieved by :

1. Reducing energetic workload through mechanisation.
2. Reducing the heat load by better ventilation or screening.
3. Machines and tools can be designed for maximum efficiency with minimum physiological cost.
4. The workers can be chosen on the basis of their physiological fitness for specific tasks, to work on furnaces.
5. Provision of air-conditioned rest rooms.
6. Adequate rest periods by adjustment of work and rest periods.

7. Organising workers' team. More workers should be added if the workload in a team is considered very heavy.
8. Compensating for sweat loss by adequate intake of water and salt. There should be easy access of cold drinking water close to the workplace.

2.4.3 Nutrition, Diets, Physical Fitness and their Relationship :

Among factors modifying physiological functions, nutrition or diet is an important factor, because it has direct relationship with calorific value which is essential to compensate energy expenditure (Kcal/min) on heavy or continuous physical (muscular) work.

As workload increases, calorie requirement increases. Insufficient calorie intake reduces work output or maximum aerobic power which can quickly be restored by improvement in diet. A well fed worker can store more energy in his fat and is able to work easily at required productivity level.

Functions of Nutrients : Diet is made of foods and foods are made of specific substances called nutrients. Each nutrient has a specific role e.g. in growth, building and repair of body, in giving heat and energy, in liberating and using energy contained in foods, in regulating other body functions and maintaining a good health.

Life functions (heart beat, breathing, digestion) and all bodily activities (muscular or mental) require, energy and heat and these are provided by the nutrients present in the foods. Balanced diet tries to contain all the nutrients in required proportion.

The energy value of food is measured in the form of beat/given off when the food is burned. The heat required to raise temperature of 1 litre water from 15 °C to 16 "C is called Kilocalorie (Kcal) or a Calorie (Cal). 1 Cal = 4.184 Joule.

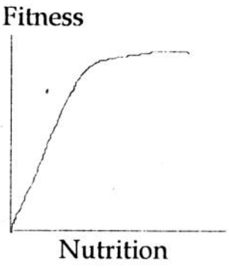
Mainly there are six categories of nutrients Proteins, Carbohydrates, Fats and Oils, Minerals, Vitamins and Water. Proteins are made of amino acids (some 23 types) and useful in body building and repair. Growing children and nursing mothers need extra protein. Cereals, nuts, peas, beans are plant sources and meat, fish, milk, cheese and eggs are animal sources of protein. Plants provide carbohydrates and also proteins, vitamins and minerals. 1 gm of carbohydrate produces @ 4 cal energy. Fats and oils are obtained from plant or animal and provide @9 cal/gm, and aid some vitamins. Minerals are needed in small quantity. Calcium in milk and milk products (except butter) is essential for teeth and bones, clotting of blood after a wound and for normal contraction of muscles. Iron is necessary for red blood cells. Iodine is a part of thyroid hormone which helps to regulate growth, mental development and rate of body functions. Vitamins (20 identified) are equally useful for growth, development and body function. Their quantity required is small. Vitamin A prevents night blindness, B protects nerves, C prevents scurvy and D ensures strong and straight bones. 60 to 70% of the human body is made up of water and it is most essential for life. Water controls the body temperature, digestion, absorption and distribution of foods to body tissues, removal of waste and functioning of the kidneys. During heavy work and in hot environment, extra water is required to compensate sweating and to keep the body temperature within limits.

Energy is always expended in work and food (nutrients) is the basic need to supply this energy. Even a simple meal provided at workplace can remarkably improve production rate and earnings.

A diet which provides enough food of different types and tastes to meet nutritional values is called a balanced diet. It varies from person to person,, states to states and countries to countries because of the varieties of factors.

Food should be fresh, warm and non-contaminated. It should be eaten after washing hands, mouth and teeth.

Nutrition and Physical Fitness Relationship :



Above discussion makes it clear that nutrition has direct relationship with physical fitness. The fitness increases with nutrition to its maximum level beyond which nutrition cannot help

Depending on quantum of physical (muscular) work, type of weather, digesting power, hunger, thirst etc., one should maintain his nutrition standard to maintain good health. More nutrition is necessary by growing children, pregnant women, nursing mothers, hard workers, athletes and people living in cold countries. To regain health after illness or injury, good and gradual nutrition is most essential. We all have to remember this relationship till our life.

3 ERGONOMICS

After studying 'Physiology' it is in chronology to study 'Ergonomics' as it includes physiological movements, measurements, limitations etc.

3.1 Introduction to Ergonomics and its Constituents :

3.1.1 Introduction to Ergonomics :

Refer Part 6.1 of Chapter-14 for meaning of Ergonomics. It is explained there for the purpose of machine guarding.

The term 'ergonomics' is derived from the Greek word 'ergo' meaning work and strength and 'nomos' meaning rule or law. It simply means "fitting the job to the worker (and not the worker to the job)". The object of ergonomics is "to achieve the best mutual adjustment of man and his work to improve his convenience, efficiency and well being". Ergonomic approach includes designing of machines, tools, controls, equipment, process, layout, housekeeping etc. to increase efficiency of both - man and the machine. Application of ergonomics reduces accidents and improves health and efficiency.

The term 'human engineering' is used in USA while the term 'ergonomics' is used in the rest of the world. Both are synonym.

Ergonomics is also defined as 'the study of human characteristics for the appropriate design of the living and work environment'. It is human centred, transdisciplinary and application oriented. It can be applied to jobs, equipment, working place, tools, utensils or any complicated working system (e.g. multiperson sociotechnical system).

Successful application is measured by improved efficiency, safety, productivity and acceptance of the ergonomic design.

The disciplines that can be utilised in ergonomics are : physiology, anthropology, biomechanics, engineering and psychology. They include both technological and human components.

Ergonomists draw data from full spectrum of human and biological sciences, technology and acquire additional data through experiment, survey and reactions to environmental hazards, sensory capacities, decision making abilities, psychomotor performance, ability to make precise, rapid and correct control movements, ability to modify behaviour through training, biological aspects of eating, drinking and waste disposal and psychological factors due to fatigue, emotion, changer etc. also become the subject matter of ergonomics.

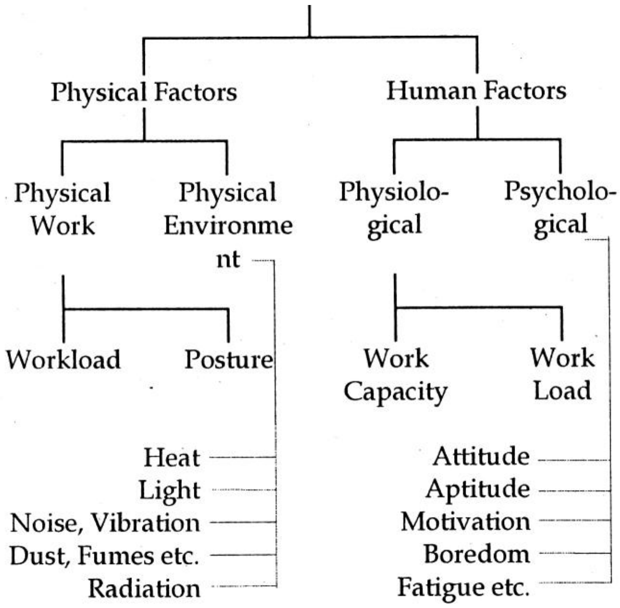
The ergonomic design should begin with an understanding of the user's role and should consider human variability as a design parameter. Tile ultimate design incorporates both human capabilities and built-in safeguards to reduce or avoid the impact of human error.

In short, the aim of ergonomics is to achieve safety, ease and efficiency at work (by considering physiological and environmental factors).

3.1.2 Constituents of Ergonomics :

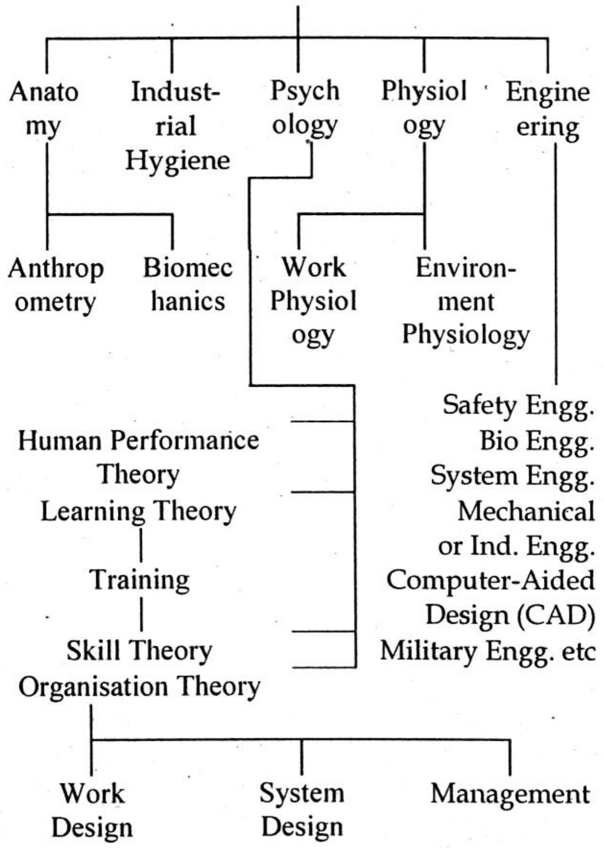
Human factors (HF) was the old discipline concerned with how humans react with their worktasks and environment aiming to make the relationship safer, healthier and more efficient. The new-name of this discipline is Ergonomics. Previously known 'Human Engineer' or "Engineering Psychologist" is now known as "Ergonomist or Ergonomicist (in great Britain). The term Ergonomics is biotechnological and covers the same scope and complexity of interests that human factors embraces. Therefore, human factors are the main constituents of ergonomics. For main division of factors affecting work including human factors see Part-5 of Chapter-3.. In a schematic diagram they are shown below :

Work Performance or Man at Work



Ergonomics studies the 'human factors' and designs the system or suggests application or modification of the existing system to make the work more suitable or convenient to the man at work. Thus in this context, or its procedural aspect, all human factors - physiological and psychological contribute in constituting the science.

But from discipline point of view, main constituents of ergonomics are anatomy, physiology, psychology and engineering. Schematic diagram of disciplines (work areas) constituting the ergonomics is also shown below :



3.2 Application of Ergonomics for Safety and Health :

Application of ergonomics can solve the problems of stress and strain due to work load, high or low temperature, more or low illumination or glare, noise, vibration, radiation, awkward work positions and orthopaedic problems due to them. The field of application is very wide which includes following as some of the areas :-

1. Hand tools.
2. Design of Controls.
3. Design of work.
4. Design of information displays.
5. Man/machine information exchange.
6. Limitations of the sense organs.
7. Age, fatigue, vigilance and accidents.
8. Problems of body size and posture.
9. Effects of climate.
10. Human energy, optimising its efficient use.
11. 'Work tolerance.
12. Anatomy of function.
13. Physiologic measurements.
14. Application of skeletal-muscular forces (e.g. manual handling and lifting.)

Ergonomics is also utilised at design stage where it is called. "System Ergonomics" in contrast to "Classical Ergonomics" which is applied to solve the ergonomic problems as and when they occur once a design has been put in use. System ergonomics is a higher level of practice involving a knowledge of (1) Different tasks the machines can perform. (2) The relative cost. (3) A variety of tasks and satisfactory work for personnel.

In designing work, ergonomics can be applied for the design of systems, work places, environments, interfaces and work situations. Some examples are as under:'

Sr. No.	Type of Design	Examples.
1	Systems	Man-machine relationship, procedure.
2	Workplace	Posture, seat and control design, bench position, displays.
3	Environmental	Required lighting, heating, ventilation, noise, vibration etc.
4	Interface	Exchange of information between man and machine / environment, scales, pointers, letters, numbers, their size, shapes, position, forces etc.
5.	Work situation	Hours of work, rest pauses, shift work, inter personal and organisational aspects of work.

Following are some of the examples of application of ergonomics (human engineering) to matters of health and safety :

1. Stresses of excessive heat, light, humidity, noise, vibration etc., their safe limits, type of worker e.g. age, sex, fitness etc., and task to be performed - all should be considered and suitable environmental conditions should be designed to fit appropriately to the worker and his task.

2. Surrounding space, seat design, bench design and positioning of displays, controls, materials, tools, equipment, instruments etc. should fit the human body so that he can work without excessive effort within the range of healthy posture.

3. Interface display and control design should consider effective information between the man and the machine or environment in type and size of numbers, letters, pointers, shapes and discrimination, identification etc.

4. Working hours, rest pauses, shift work, interpersonal and management problems should be studied and resolved to maintain health and safety of work people.

5. It should be aimed to do work with a minimal use of energy and materials and without waste resulting from mistakes. Human errors should be minimised for safety and health.

6. Design and production of automotive vehicles, communication equipment, farm machinery, military service, aerospace systems, computers and electronic equipment can be made safe and most suitable to the operators.

7. Highway signs, typewriters, data processing systems, machine tools, kitchen stoves, street and highway design, rapid-transit facilities, health facilities, housing , pollution control, education, law enforcement, postal service, airports etc. are newer areas where ergonomic design can give good results and reduce accidents.

8. Deciding allocation of functions between men and machines. Functions' of perceiving, responding to emergency situations, some ' typical judgements etc. are better done by men than by machines. Functions of heavy lifting, computing, auto regulation, handling large amount of information etc.

are better performed by machines than by men. These are to be considered at an early stage of design.

9. Task analysis to decide selection standards, workloads, training requirement, manpower requirement, equipment design can be carried out.

10. Factors of control design, e.g. control display ratio, safeguards against accidental activation, control coding etc. are part of ergonomic design.

11. Workplace dimensions, location of controls and displays, seat and penal design, the design of doors and access for easy entry and exit and protective devices for emergency situations need to be well designed.

12. For good maintenance easy and simple maintenance manuals, tools and test equipment, better location of units for easy access, faultfinding techniques etc. are to be designed properly.

13. Allowance for local weather conditions, ventilation in cramped premises, providing stool to put container to avoid frequent bending, elementary checklists are ergonomic aspects.

14. Manual material handling has a large scope of ergonomic considerations. Process flow, job design, layout, selection of equipment, machine, tools, space requirement, control design, visibility, colour and signs, allowing push and pull instead of lift and lower, avoiding severe bending, lifting and lowering between knuckle (hip) height and shoulder height, avoiding excessive weight, avoiding sharp edges, corners, pinch points, training for safe lifting practice and lifting rules (dos and don'ts), personnel selection etc. must be well considered.

15. Wrong design of hand tools can create bending of wrist, pressure points between the hand and the handle, sustained exertions, vibrations etc. Therefore handtools should be designed in such a way that they eliminate or minimise these hazards. Oblique angle of the handle, proper shape, diameter and length of the handle, rounding off all edges and sharp corners, minimising noise and vibration etc. are useful criteria.

16. Office, other work places and workstation design call for specific criteria. Ideal, practical and detail planning, work process, equipment, workplace layout, final enclosure, mock-up, trial and redesign, clearance for the operator's body, sufficient head room, visual field, auditory information, standing or sitting position (both have advantages and disadvantages), work space dimensions, body position to operate computer, healthy work postures, eye height, elbow height, knee height, seat design to reduce physiological and biomechanical stresses by providing wide range of adjustments and postures to suit the individual (seat height adjustable between 15 to 20 inch, deep 15 to 17 inch, wide 18 inch or more and backrest to support back and neck and opportunity to change body posture frequently) etc. are some important criteria:

17. Controls - continuous or detent - should be designed by considering consistency of movement, control actuation force, multidimensional operation, operator-control orientation, control-effect relationship, time lag, arrangement and grouping, coding and prevention of accidental activation etc.

18. Light signals provide useful safety and functional indications as mentioned below : See also Part 7.3 of Chapter-9.

19. Displays provide necessary information to the operator. They may be visual (lights, scales, counters), auditory (bells, horns), tactile (shaped knobs. Braille writing) or audio-visual (buzzer with light, TV display). Selection depends on type of information to be provided and to whom provided.

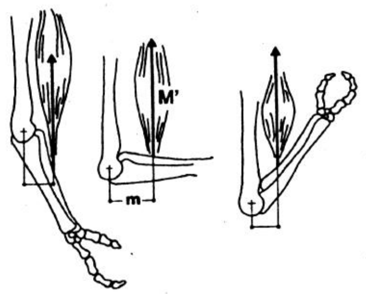
20. Labelling permits rapid and accurate performance of controls, displays and other items that should be identified, read, manipulated or located. Label characteristics are: accuracy, time of response or recognition, distance, illumination, nature of function and consistency. Their visibility, legibility, location, orientation, abbreviation, brevity and standardisation are necessary. Legal notices must be displayed.

From. above varieties of examples it is evident that ergonomics has wide applicability to many functions in addition to health and safety.

3.3 Load Carrying :

3.3.1. Safe Use of Muscle System & Lever System in Load Carrying.

Muscle system consists of about 200 skeletal .muscles in the body. They are in the form of bundles of muscles and wrapped on each other. They are connected with tissue carrying nerves and blood vessels inside. The tissues combine to form tendons which connect the ends of the muscle to bones. The sheaths of the connective tissues provide mechanical properties to the muscle.



A muscle has only action to contract. Elongation is by external force. Filaments of muscle sliding along each other provide automatic contraction after elongation. Signal to contract comes from brain by the neuromuscular system. Signals coming to motor units of the muscle can be observed by electromyogram (EMG).

Lever system is consisted of links (bones) joined in their articulations and powered by muscles bridging the joints. As elbow angle changes, lever arm (LA) also changes with the muscle force (MF).

Safe use of these muscle and lever system of human body is most desirable to prevent injury, damage or pain to the body. Excessive load causes excessive stress in muscle which may result in strain, stretch or pain. Therefore excessive weight limits are legally prescribed. Some safety measures are as under:

1. While handling material, force exerted by hands should be transmitted through the whole body parts including feet to the floor. In this chain of forces, weak link is spinal column, particularly at the low back. This limits the capability of a person to work. Therefore task should not be too heavy.
2. Tasks, equipment and system should be designed to provide ease and efficiency of manual handling.
3. Layout of material transfer and facilities should be convenient and comfortable to the people.
4. Job design should be safe, efficient and agreeable for the worker.
5. Selection of tools, machines, equipment should be proper. Sufficient space for movement, visibility, lighting, colour coding and control design are important.
6. Select persons capable of performing the job. The job should be designed to fit the worker.
7. Give training for safe lifting practices.

3.3.2 Physiological Problems with Load Carrying (Injuries, Fatigue etc.) & their Solutions.

Problems with load carrying activity are as under:

1. Limits of human capability of movement in body joints and in spinal column, body size, sex, age, energy capacity (heart rate), etc. Therefore load carrying capacity varies with age, sex and overall strength of a person..

2. Physical Fatigue due to overexertion that causes temporary decrease in physical performance. Reasons of fatigue are workload i.e. static and dynamic work, lack of rest or sleep, illness, pain, poor food intake etc.

3. Mental fatigue due to psychological factors like monotony, conflict, worry, de-motivation etc.

4. Work and rest cycle depending on intensity of work. Heavy work requires more rest periods at short interyals.

5. Faulty layout of material transfer requiring more time and more effort.

6. Wrong design of job. Where machine is required, job is given for manual working or carrying. Excessive weight, odd size, sharp edges, hot material, oily or slippery surface, invisibility etc are some of such factors.

7. Non-provision of sufficient space for movement, necessary hand tools, proper controls, signs (e.g. arrow) for lifting or placing etc.

Solution to above problems require -

1. Decision whether man is required or machine is required for a particular job.
2. Weight should be within limit i.e. not excessive for a person to be employed.
3. Proper design of job itself and of facilities, tools and equipment etc.
4. Sufficient space for movement, illumination, necessary rest intervals, proper clothing, drinking and food arrangement etc.
5. Proper selection of persons based on their size, sex, age, strength etc so that work matches with the people.
6. Break down whole material movement process from receiving to distribution into different functions or segments and in each such division plan the actives of material handling in detail and separate out jobs for machines and men. Then allocate accordingly.
7. Plan movement of material in horizontal plane. Arrange push or pull instead of lift or lower. Avoid severe bending movement.
8. Delivery of material at workplace should be at hip height instead on ground floor.
9. Lifting and lowering height should be between hip and shoulder height. This will cause less injury.
10. Handling should occur close to and in front of the body.
11. Material should be light, compact and easy to grasp. It should not have sharp edges, corners or pinch points.
12. Containers or bins should be of sufficient size. Material can be put or removed easily.

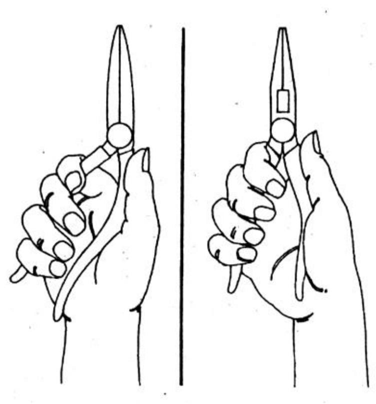
See also part 2 of chapter 15 for manual material handling.

3.4 Hand Tools and their Use :

See Chapter 17 for figures and other details of safe use of hand tools and power tools.

3.4.1. Design of Tools in relation to Body Postures.

Ergonomic design of hand tools is necessary so that tools and their handles properly fit to the hand grip, avoid unnecessary bend, movement or pressure of fingers and wrist, provides smooth surface and shape for safe handling, insulation for electrical tools and requires less force while working. Some such design criteria are as under -



1. Tools should have bend and should be best fitting to the shape, size and functions of the hand.
2. There are different interactions between the hand and the handle, control or support viz. finger touch, palm touch, hook grip, tip grip, pliers grip, side grip, writing grip, disc grip, finger palm enclosure, power grasp etc. Handle, control, knob, lever or support should be properly designed for such couplings between hand and handle, control etc.
3. Cross section and longitudinal shape of the handle must be proper. Circular cross section is mostly preferred.
4. Handle size should accommodate the palm for sufficient grip.
5. Pressure points and rough surface of handle should be avoided.
6. Round off sharp edges or corners on the handles for safe holding.
7. Avoid cooling or heating the hand by appropriate covering (insulation) on handle.
8. Hand tools should have minimum vibration. Gloves should be used if useful.

3.4.2 Safety while using Hand tools.

See part 3.2 of Chapter - 17

3.4.3 Safety while using Power tools.

See Part 4.1 of Chapter - 17

3.4.4 Tool boxes. Kits & Tool maintenance.

See Part 3.4 and 4.2 of Chapter - 17

3.5 Work Station Design:

3.5.1. Introduction to Anthropometry.

Anthropometry and biomechanics are branches of ergonomics dealing with physical dimensions and properties of. the human body.

Anthropometry means measuring the human body. Height, breadth, depth and various distances of the body parts are measured. Curvatures and circumferences are also measured. Measurements are taken in stand-erect or seated position.

Body dimensions are measured by anthropometers, calipers, taps and a scale. Such dimensions are useful in designing work spaces, tools, equipment, seating arrangement, vehicles and workstations so that' they can best fit to the users.

3.5.2. Concept of Percentiles.

Percentile indicates which percentage of a known population is fitted by a design range. Suppose work seat height is to be designed most convenient to majority of men and women, its range should fit to the women in 5^{th} percentile to the man in is 95^{th} percentile. This means much deviation will not be required in this range of seat height (say lowest 35.5 cm to its highest setting at 48.8 cm). Then addition of 2 cm for heal height may be required. 50^{th} percentile corresponds to a single fixed seat height of 41 cm for a mixed malefemale population, but, this will be too high for about 50 % of the people and too low for the rest. Thus designing for the average fits nobody.

5^{th}, 50^{th} and 95^{th} percentiles measurements for human height, depth, breadth, head, hand and foot dimensions are available for ergonomic design purpose.

3.5.3. Health problems related to wrong postures, back pain etc.

Sitting or standing in the same posture for a long time exert muscle tension and spinal compression. Therefore this should be avoided by providing rest periods, physical activities or exercises.

Computer operators keep the head in a fixed position for a long time and therefore suffer pain and tension in the neck area. Intensity, frequency and long hours of muscle contractions cause severe discomfort, pain and other musculoskeletal disorders that last for long periods.

Lumber spine suffers more force while sitting on a stool without backrest than in standing at ease. Leaning back over the backrest and arms hanging down reduces compression force. Straight upright backrests do not support the body and high disk forces may occur. When it is declined back and upper body weight is rested on backrest, internal forces are also declined. Relaxed leaning on a declined backrest is the least stressful sitting posture.

See Part 2.4.1 of Chapter 15 also. See Part 13.4.4 of Chapter-5 for musculoskeletal and trauma disorders to computer operators.

3.5.4. Ergonomic Office Furniture and Utility Tools.

Workstation consists of furniture, equipment, work material and overall environment. Persons do job there. Work posture includes movement of body parts and work activities include visual, auditory, vocal and motor types. Their combined effect is performance output and persons' well being.

Work space design, good lighting and ventilation, attractive and comfortable work situation are basic requirement. Office furniture and utility tools like controls, displays, switches, trays, bins, office equipments and instruments also play an important role.

General system components include computers, keyboards, tables, chairs and cupboards. But operator is the most important component in this system, because work output depends on him and he utilizes other components of the system. He should be most comfortable. His body dimensions are useful in designing workstation dimensions as under -

1. Dimensions should be slightly adjustable according to individual's requirement.
2. Visual tasks - monitor, key board, papers, books etc. - should be at eye height.
3. Keyboard, mouse, notepad, pen and hand controls should be convenient to elbow height and forearm length.
4. Leg room height depends on knee height, and thigh thickness and its depth depend on foot length.
5. Thigh width and lower leg length (Popliteal height) decide the width and height of the seat pan.
6. Functional reach decides height of shelves and other furniture.
7. Furniture should provide user freedom to extend legs or hands, to lean foreword or backward, to rotate left or right and to take any posture.
8. Ergonomic chairs with large backrest are most comfortable as they provide support to back and neck. Seat height must be fully adjustable, (height 35 to 50 cm, depth 35 to 45 cm and width 45 cm). Seat surface should not generate any pressure to the seated person.
9. Armrests are useful in reducing compression load on the spinal column.
10. Visual targets should riot be spaced apart in direction or distance from the eye. They should be easily viewable in the front.
11. All components of workstation should fit each other and each should fit the operators. Flexibility for individual requirement is also necessary.

3.6 Machine Controls and Displays:

3.6.1. Location & Sequence of Operation.

Controls are mostly hand or foot operated. They transmit inputs to machine, vehicle or equipment. They are selected on basis of their functional utility and located in easy reach so that operator's body parts are not overstressed.

Controls are of 'continuous' type (e.g. crank, knob wheel etc) or 'detent type (e.g. key lock or switch, bar knob, thumbwheel & different switches) where step wise operation is required.

Controls having sequential relations should be arranged in functional groups with their associated displays and in operational sequence.

If sequential operation follows fixed pattern like car gear handle, they should be arranged to facilitate operation i.e. top to bottom or left to right. Sufficient spacing s required for movement.

Controls should be located as per operator's requirement i.e. easy operation. Time lag between control input and system response should be minimum and consistent with safe and efficient operation.

Knobs are provided where little force is required and when fine adjustment is necessary.

Hand wheels are used for two hand control. Then knurling (corrugation) should be provided for good grasping.

When levers are used for fine or frequent adjustment (e.g. car gear lever) limb support are useful. e.g. elbow support for large hand movement, forearm support for small movement and wrist support for finger movement.

When several levers are located side by side, the lever handles should be coded. Levers should be labeled for their direction of motion and function. For joystick controls (three dimensional steering), elastic resistance is added for smooth displacement.

3.6.2. Natural Expectation of Control Movement.

Control movement should match with natural expectation e.g. foreword motion for front driving, backward motion for reversed driving, clockwise motion for right direction and anticlockwise for left direction, forward motion for boom descend and viceversa. In electrical switches, downward indicates 'on' and upward indicates 'off position. This is natural expectation.

In key lock switches (e.g. car ignition switch), key's vertical position indicates 'off position, turning clockwise indicates 'start' position and key should not come out without turning the switch i.e. without stopping the vehicle or machine. The 'on' and 'off positions should be labeled.

3.6.3. Preventing Accidental Activation.

Controls should be so designed and located that they will not move or change their position accidentally. They should not come out accidentally or by slight touch from 'off to 'on' position and start the vehicle or machine [Section 24(3) of the factories Act]. Such inadvertent operation can cause 'accident to person, machine or system. To prevent such accidental activation, following measures are useful

1. Cover or guard the control.
2. Provide interlock so that extra movement is required to change the position.
3. Provide resistance by spring action or viscous friction so that extra effort is required for actuation.
4. Provide rotary action for operation.
5. Provide recess, slot, shield etc to contain controls within it and finger is required to insert inside. e.g. push button or switch in recess or guard on foot pedal of a power press.
6. Provide 'on' and 'off .button separately and with different colour.
7. Provide' Dead man control' which will keep the system working till the control is pressed and will stop the system when the control is released, e.g. petrol nozzle trigger (knob) or drill machine push button.

3.6.4. Foot controls.

Foot controls have specific use and where powerful braking force is required or when leg is only convenient limb, viz. brake pedal or acceleration control lever in car or brake pedal for power press, press brake, metal shear and other machines.

3.6.5. Displays and Light Signals.

These are useful to provide, necessary information to operator. They may be dial gauges, pointers, digital, audio, visual, analog etc. Bell, horn and warning notices are also displays which give information. Colored signals have some meaning as under

1.	Red	-	Stop position
2.	Flashing Red	-	Emergency condition.
3.	Green	-	'On' position or 'yes' indication to proceed..
4.	Yellow	-	Wait, delay or be in readiness position. It also indicates caution or rechecking.
5.	White	-	No right or no wrong, transitory condition.

Displays should have clear meaning. They should be easy to understand and visible, properly illuminated, also visible when power fails, coded and labeled according to function.

Numerical display indicates time, temperature, pressure, flow, humidity, pH, speed etc. Moving pointer on a fixed scale 'have many shapes - circular, curved, horizontal straight or vertical straight. Numbers or figures should not be obstructed by pointer.

Displays should be located in viewing area and perpendicular to the line of sight.

Labels should be provided where extra information is necessary.

4 OCCUPATIONAL HEALTH

4.1 Meaning :

Occupational Health is eventually a branch of preventive medicine which examines the relationship between work and health and effects of work on the health of the worker.

Occupational Health includes all factors relating to work and working conditions, methods and environment, that may cause diseases, injuries or deviation from health including maladjustment to work. It implies not only health protection but also health promotion for improving the health and working capacity of the worker, viz. preventive measures against diseases, improvement of nutrition and general mental health.

Occupational Health was defined by ILO/WHO committee in 1950 as "Occupational health should aim at: the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations, the prevention among workers of departures from health caused by their working conditions, the protection of workers in their employment from risks resulting from factors adverse to health, the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological ability and to summarise : the adoption of work to man and of each man to his job."

It includes medical examinations of workers, their health records, placement according to health condition and adjusting work to man and man to his work. It is a team work of chemists, .safety professionals, industrial hygienists and doctors.

4.2 Occupational Diseases :

4.2.1 Common Occupational Diseases :

(1) Occupational Lung Diseases :

Normally dusts cause lung diseases and therefore the types of dusts and their effects are discussed below.

(A) Types of Dusts and their Effects :

Dust is a disperse system (aerosol) of solid small particles in air or gas whose size distribution is like a colloid. It originates from mechanical communication of coarser material. Mining, breaking, crushing, grinding, mixing, polishing and handling are the main dust generating processes.

Small particles of O.I to 5 u.m size (respirable dust) can remain in the alveolar passages of which smaller particles (O.I r-lm) behave as colloids or smoke, deposit in lungs or other part and cause health effect. Particles of larger size (>5 (im) are driven back by the clearance mechanism. Asbestos fibre of 3 (urn or less in diameter and upto 100 (im length can reach the alveoli, while the smallest fibres can reach upto pleura and pleural space.

2nd Schedule of the Factories Act prescribes TLV (permissible time-weighted average i.e. TWA concentration per 8 hours) of cotton, asbestos, coal, cement and silica dusts.

Types of dusts can be classified as under :

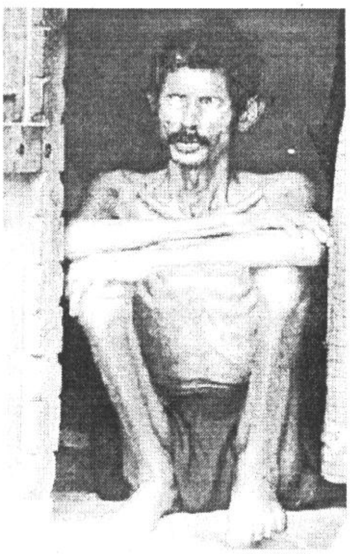
1. Quartz and mixtures containing quarts : Coal dust, mineral ores, sand, rock, fluorspar, quartzite etc. They are found in mining, ceramic industries, refractories, pastering, mixing and insulating materials. They cause nodular fibrosis and silicosis.
2. Asbestos and mixtures containing asbestos : Raw asbestos, chrysotile, amphibole, asbestos cement talk etc. It ir vsed in some 3000 products of textile,, insulation, packing, jointing and building material. It can cause diffuse fibrosis, carcinoma, asbestosis and telcosis.
3. Metals and metal compounds : Metals like iron, nickel, lead, manganese, aluminium, beryllium, chromium, cadmium, vanadium and their oxides are extensively used in metallurgy, metal working, welding, electroplating, furnaces, sintering etc. They can cause irritation, diffuse fibrosis and different types of lung diseases known as siderosis, bronchial carcinoma or asthma, tracheobronchitis, aluminium lung etc.
4. Plant and Animal (organic) dust : Wood, animal hides, skins, hair, feathers, scales, cotton flax, hemp, sisal, jute, mouldy hay, straw, cereals, bagasse, crushed grain and bran, enzymes etc. They are found at wood working, agriculture, poultry, textile, grain or sugar mill etc. and cause irritation, immune reaction, carcinoma, allergic rhinitis, bronchial asthma, farmer's lung, bagassosis, byssionosis etc.
5. Other dusts : These are chemical dust like carbon dust, soot, graphite, phthalic and maleic anhydride and arsenic dust etc. and found in mining, metallurgy, rubber, plastic and chemical industry. They can cause irritation, carcinoma, systemic effect, ulceration, conjunctivitis, graphite pneumoconiosis etc. Inert dusts are also hazardous.

Following table shows some dusts and lung diseases that may be caused by them.

Dusts	Lung Diseases
Quartz (Silica)	Silicosis.
Asbestos	Asbestosis
Talc	Talcosis, mesothelioma, bronchial carcinoma, carcinoma of upper respiratory tract.
Aluminium and its oxides	Aluminum lung, bauxite smelter's lung, CNSLD
Beryllium & its oxides	Tracheobronchitis, penumonitis, beryllosis
Cdadmium and its oxides	Tracheobronchitis, bronchopneumonia, emphysema of the lung.
Chromium, Chromate, Chromoxide	Ulceration and perforatin of nasal sputum, bronchial asthma, carcinoma of nasal cavity, CNSLD.
Hard metals	"Fibrosis, immune reaction.
Iron, Iron oxide	Siderosis.
Manganese, Manganese oxide	Manganic pneumonia, CNSLD.

Nickel, Nickel oxide, Nickel salts,	Bronchial carcinoma, carcinoma of nasal cavity,
Platinum compounds (salts)	Allergic rhinitis, bronchial asthma.
Vanadium pentoxide	Tracheobronchitis, bronchial asthma, CNSLD.
Milled or crushe grain and bran	Allergic rhinitis, chronic rhinitis, bronchial asthma CNSLD.
Wood (exotic types)	Allergic rhinitis, bronchial asthma, carcinoma of the nose and nasal cavity, CNSLD.
Animal hides, skin, hair, leather and scales.	Allergic rhinitis, bronchial asthma.
Mould hay, straw, cereal, and bagassse	Farmer's lung, bagassosis.
Enzymes	Allergic rhinitis, bronchial asthma
Cotton, flax, hemp sisal, jute.	Byssionosis, CNSLD.
Arsenic, arsenic trioxide, arsenic salts.	Ulceration and perforation of nasal septum, trecheobronchitis, carcinoma of nasal cavity.

(CNSLD : Chronic non-specific lung disease)


Effect of Silica Dust

Biological effects have been well established and have recognised specific illness due to specific dust, e.g. silicosis due to silica, siderosis due to iron, byssionosis due to cotton dust etc. Where there is no specific clinical picture, the case is referred as CNSLD i.e. chronic non-specific lung disease. The types of effects are fibrogenic, carcinogenic, systemic, toxic, allergic, irritant and skin effects.

For silicosis, Siderosis and Anthracosis see Part 9 of Chapter 20 and for Byssionosis see Part 10.1 of Chapter 21.

(B) Dust Control Methods :

To prevent lung diseases, some control measures areas under

1. Know the exposure limits of dusts. Dust below 5 microns size is invisible. Depending on toxicity, exposure limits vary from 0.1 to 10 mg/ m^3 See also 2nd Schedule under the Factories Act (Table 15 of Chapter-32). Employ effective measures based on this safe limit and nature of the dust.

2. Elimination of dusty process e.g. improved casting technique to eliminate dusty fettling process.

3. Substitution by a less toxic or non-toxic dust, e.g. shot-blasting in place of sand blasting, metal moulds in place of sand moulds and glass fibre or slag wool in place of asbestos insulation.

4. Segregation and enclosure of the process if dust generation cannot be prevented. Dusty process should be enclosed in a room and be connected with effective exhaust and dust collector. - Complete enclosure is the best segregation, e.g. blasting cabinet, fuming cupboard.

5. Wet methods prevent particles becoming airborne. Powdered material is suspended or dissolved in a liquid. The correct degree of wetting should be maintained and it should not be allowed to dry out.

6. Local exhaust ventilation should be applied to collect the dust from the nearest possible distance. The smaller enclosure gap requires smaller exhaust rate. Suction flow should be away from the

worker's breathing zone. Dust collection, filtration and disposal are the subsequent steps. Various kinds of air cleaning devices are also available.

(2) Occupational Dermatitis :

An inflammation of the skin produces dermatitis which is the most common skin disease. The part of body most exposed is affected first, so it starts on hands. With some dusts and fumes, the first signs may appear around the eyes, neck and face also. The disease can be caused by many chemicals and apparently harmless substances including all forms of mineral oils (including diesel, lubricating and fuel oil); chemicals (alkalis, chromate, dichromate and synthetic resin), solvents (thinners and degreasers such as white spirit, paraffin, trichloroethylene, turpentine, and petroleum product); tar pitch and other coal products including chemicals in the phenol and cresol family; soot; radiation including X-rays and radiant heat; friction particularly when dust or grit gets between clothing and skin.

Contect dermatitis

Chromate and dichromate used in chromium plating, dyeing and tanning produces chrome ulcers or holes as well as dermatitis. In one chemical factory at Vadodara (Gujarat), 43 workers with holes in nasal diaphragm, 3 workers with chrome ulcer and 23 workers with dermatitis were detected. They were working with sodium and potassium dichromate. The liquid or dust from the process gets into cracks or cuts in skin and forms deep holes. Chromic acid, concentrated potassium dichromate, arsenic trioxide, calcium oxide, calcium nitrate and calcium carbide are well known ulcerogenic chemicals. Chemical or thermal burns, blunt injury or infections resulting from bacteria and fungi may result in ulcerous excavations on the part affected.

Occupationally induced changes in skin colour can be caused by dyes, heavy metals, explosives, certain chlorinated hydrocarbons, tars and sunlight. The change in skin colour may be simply a chemical fixation within keratin.

Primary Skin Irritants in industry are organic and inorganic acids and alkalis, some metal salts, nickel, phenol, trichloroethylene, solvents and acne producers.

Primary Skin Sensitizers are dyes and dye intermediates, photographic developers, rubber accelerators and anti-oxidants, insecticides, oils, natural and synthetic resins, coal-tar and its derivatives, explosives, plasticizers and others.

Skin cancer is caused by long periods of contact with a variety of substances including mineral oils, paraffin, tars, arsenic and several kinds of radiation including X-rays and ultra violet light. The cancer will usually develop in direct contact with the above substances. Other parts can be affected.ifthe substance penetrates the clothing.

Dermatitis is a skin disease caused by primary irritants like acids and alkalis, organic solvents, soaps, detergents, lime, cement, turpentine, synthetic coolants, abrasives, nitropaints, hardeners, dyes, peroxides, pesticides, weedicides, gum, inks, chlorinated diphenyls, disinfectants etc. and by sensitizers like formaldehyde, fungicides, azo dyes, chromium, nickel, mercury and cobalt salts.

Dermatitis can also be caused by physical agents (e.g. heat, cold, moisture, radiation, friction, pressure etc.) or biological agents (e.g. bacteria, fungus, virus etc.)

Occupations involved are leather, metal, paint, printing, plastic, rubber, textile, electroplating, engineering, construction, cleaners, chemical, bakers etc.

Signs and symptoms are eczematous lesions.

For diagnosis it is useful to know the occupational history and to observe many workers, in identical situations, who develop cutaneous changes. Patch tests are indicative.

Occupational dermatitis is preventable if timely diagnosed and controlled. Preventive measures are :

1. Engineering measures to control the harmful agents by various methods.
2. Pre-employment or pre-placement medical examination and sorting out the workers having suspected dermatitis or pre-disposition to skin diseases and keeping them away from the jobs having skin hazards.
3. Use of .necessary PPE and barrier creams.
4. Personal hygiene. Adequate washing and bathing facility with warm water, soap, nail cutter and clean towels.
5. Periodical medical examinations of workers and transferring the job of the affected workers.

(3) Occupational Cancer :

Occupational cancer is a form of delayed toxicity, serious in clinical course and outcome, due to exposure to chemical or physical agents (carcinogens) in the workplace.

Following figures of ESIC indicate incidence of cancer in our workers :

Year	Total insured workers (lakh)	Workers having cancer	Cancer workers per 10000 workers
1983-84	63.00	1890	3
1984-85	61.61	1848	3
1985-86	61.52	1235	2
1987-88	61.09	2414	4
1988-89	59.97	599	1
1992-93	66.91	14720	22
1993-94	66.24	6630	10

In Gujarat, in 1993-94, new 36 workers were detected for this disease. Most of these cancers may be occupational.

Carcinogenic substance means a substance or preparation which by inhalation, ingestion or cutaneous penetration can induce cancer or increase its frequency. It causes an increased incidence of benign and/or malignant neoplasm, or a substantial decrease in the latency period between exposure and onset of neoplasm in human or in experimental specie; as a result of any exposure which induce tumours at a site other than the site of administration.

It is unknown that how many chemicals are actually carcinogenic to humans and how many human cancers could be prevented by improving working conditions. There may be mixed reasons occupational and non- occupational also.

The ACGIH has classified carcinogens in five categories:

A1 - Confirmed Human Carcinogen

A2 - Suspected Human Carcinogen
A3 - Animal Carcinogen
A4 - Not classified as a Human Carcinogen .
A5 - Not suspected as a Human Carcinogen

Some such carcinogens are listed below with their TLVs(TWA) and above category.

Carcinogens, TLVs and Category

Substance	TLV (TWA)		Category
	PPM	Mg/m^3	
Acrylamide	-	0.03	A3 skin
Acrylonitrile	2		Skin
Allyl chloride	1		A3
Aniline	2		A3 skin
Antimony trioxide	-	-	A2
Arsenic as As	-	0.01	A1
Asebstos, all forms fibre cc	0.1	-	A1
Benz (a) anthracene	-	-	A2
Benzene	0.5	-	A1 skin
Benzidine	-	-	A1 skin
Benzo (a) pyrene	-	-	A2
Beryllium as Be	-	0.002	A1
1.3 Butadiene	2	-	A2
Cadmium	-	0.01	A2
Carbon tetrachloride	5	-	A2 skin
Chloroform	10	-	A3
Bis Chloromethyl ether	0.001	0.0047	A1
Chloromethyl methyl ether	-	-	A2
Coal tar as benzene soluble	-	0.2	A1
DDT	-	1	A3
Diazomethane	0.2	-	A2
Ethyl acrylate	5	-	A4
Lead chromate			
- as Pb	-	0.05	A2
- as Cr	-	0.012	A2
β-Nephthylamine	-	-	A1
Nickel-soluble inorganic	-	0.1	A4
Compounds o or p-Toluidine	2	-	A3 skin
1, 2, 3	10	-	A3 skin
Trichloropropane			
Uranium compounds as U	-	0.2	A1
Vinyl bromide	0.5	-	A2
Vinyl chloride	1	-	A1

Zinc Chromates as Cr	-	0.01	A1

Courtesy : 2007 TLVs and BEIs, ACGIH.

Some tables are also given below to understand occupation or substance and body part (site) being affected by cancer.

Occupation, Substance and Site of Cancer:

Occupation	Substance (carcinogen)	Site (body part)
Asbestos & products	Asbestos	Lung, pleura
Metal and Mining	Arsenic, Chromium, Uranium, Benzo (a) pyrene (BAP), Nickel	Lung, skin Lung Lung Lung Lung, nasal sinuses
Chemical industry	Vinyl chloride BCME, CMME Dyes-bendizine, s-naphthylamine, 4-aminodiphenyl Auramine, other aromatic amines Isopropyl alcohol	Liver Lung Blader Bladder Paranasal sinuses
Petroleum industry	Polycylic hydrocarbons	Scrotum
Insecticide, Pesticide	Arsenic	Lung
Gas industry	Benzo (a) pyrene (BAP) Coal carbonization products, β-naphthlamine	Lung Lung, Bladder Scrotum
Gas industry	Benzo (a) pyrene (BAP) Coal carbonization products, β-naphthylamine	Lung Lung, Bladder Scrotum
Rubber industry	Benzene Aromatic amines	Lymphatic and Leukaemia Bladder
Leather industry	Leather dust, benzene	Nose, bone marrow
Wood pulp and paper industry	Wood dust	Nose (adenocarcinoma)
Roofing, asphalt work, steel prod.	BAP	Lung
Others – Diethylstil	Diethylstilboestrol Melphalan Mustard gas	Female genital tract, breast Haematolym phopoietic system Lung, pharynx Skin, lung, bladder, GIT

	Soots, tars and mineral oils Conjugated oestrogen Cyclophosphamide	Uterus Bladder

Body part and Substance having risk of Cancer :

Body part	**Substances (carcinogen)**
Bone	Beryllium (benzene – bonemarrow)
Brain	Vinyl chloride
Gastrointestinal tract (GIT)	Asbestos
Heaematolym phopoietic tissue (leukaemia)	Benzene, styrene, butadiene and other synthetic rubber, alkilating agent, cyclophosmamide, melphaln, busuphan, vinyl chloride
Kidney	Lead, coke oven gas, finasetin
Liver	Alcohol, vinyl chloride, steroids, eflatoxin, DDT, PCB, trichlor ethylene, chloroform, aldrin, dieldrin heptachlor, chlordecon, mirex, CCl_4
Liver	Alcohol, vinyl chloride, steroids, eflatoxin, DDT, PCB, trichlor ethylene, chloroform, aldrin, dieldrin heptachlor, chlordecon, mirex, CCl_4
Larynx	Tobacco smoking, alcohol, asbestos, chromium, mustard gas.
Lung	Tobacco smoking, arsenic, asbestos, iron, chromium, nickel, vinyl chloride, cadmium, uranium, bischloromethyl ether (BCME), chloromethyl methyl ether (CMME), benzo(a) pyrene (BAP), coke oven gas, mustard gas, tar, polyclinic hydrocarbons (PCH)
Lymphatic tissue	Arsentic, benzene
Mouth	Alcohol, pan, lime, tobacco, gutkha, textile fibre
Nose	Chromium, nickel, wood dust, leather dust, tanning, formaldehyde, IPA, benzene
Pancrease	Benzidine, PBC
Peritoneum	Asbestos
Pharynx	Tobacco smoking, alcohol, mustard as, textile fibres
Plural cavity	Asbestos
Prostate	Cadmium
Scrotum	Soots, tar β–naphthylamine, chloroprin, polyclinic hydrocarbons (PCH)
Skin	Arsenic, cutting oil, mineral oil, soots, tar, cock oven as, PCH
Bladder	Tobacco smoking, α or β-naphthylamine, benzene, benzidine, 4-aminodiphenyl, alkilating agent, chlorophosmamide, auramine, 4-nitrodiphenyl, aromatic amines
Vagina	Oestrogen
Female genital tract, breast	Diethylstillboestrol
Central nervous system (CNS)	Vinyl chloride

Uterus	Conjugated oestrogen
Buccal cavity	Oil mist, solvents, dyes, cadmium, lead
Multiple myeloma	Solvents

Diagnostic methods for assessing cancer should consider detailed occupational history to know whether in past the worker was exposed to any carcinogen. If worker does not know it, factory records should be gone through or interrogated with his supervisors. A questionnaire may be useful in 'collecting such past information. Screening may be useful to some extent.

Preventive measures are

1. Not to use carcinogenic .substances or processes.
2. Research to find safe substitutes should be developed.
3. To eliminate contact of workers from carcinogenic substances by
   (1) Employing closed system of work (i.e. no manual handling or direct exposure).
   (2) Work environment monitoring, biological monitoring and keeping the exposure far below the permissible limits.
   (3) Using personal protective equipment.
   (4) Following safe waste disposal methods.
4. Avoiding personally susceptible workers at the time of recruitment.
5. Rotating workers exposed to risks and thus reducing their exposure time.
6. Advising to stop smoking and to improve personal hygiene.
7. Referring serious cases to a cancer hospital or onco-surgeon.

4.2.2 Notifiable Diseases under the Factories Act 1948 :

Following four sections of the Factories Act are relevant:

Section	Provision
89	Notice of certain diseases.
90	Power to direct
91	Power to take samples.
91A	Safety and Occupational health surveys.

Under Sections 89 and 90 above, the Third Schedule gives a list of Notifiable (occupational) Diseases as under :

1. Lead poisoning including poisoning by any preparation or compound of lead or their sequelae.
2. Lead tetra-ethyl poisoning.
3. Phosphorus poisoning or its sequelae.
4. Mercury poisoning or its sequelae.
5. Manganese poisoning or its sequelae.
6. Arsenic poisoning or its sequelae.
7. Poisoning by nitrous fumes.
8. Carbon disulphide poisoning.
9. Benzene poisoning, including poisoning by any of its homologues, their nitro or amino' derivatives or its sequelae.
10. Chrome ulceration or its sequelae.
11. Anthrax.
12. Silicosis.
13. Poisoning by halogens or halogen derivatives of the hydrocarbons of the aliphatic series.
14. Pathological manifestation due to (a) Radium or other radio-active substances, and (b) X-rays.

15. Primary epitheliomatus cancer of the skin.
16. Toxic anaemia.
17. Toxic jaundice due to poisonous substances.
18. Oil acne or dermatitis due to mineral oils and compounds containing mineral oil base.
19. Byssionosis.
20. Asbestosis.
21. Occupational or contact dermatitis caused by direct contact with chemicals and paints. These are of two types, that is, primary irritante and allergic sensitizers.
22. Noise induced hearing loss (exposure to high noise levels)
23. Beryllium poisoning.
24. Carbon monoxide (poisoning).
25. Coal miners pneumoconiosis.
26. Phosgene poisoning.
27. Occupational cancer.
28. Isocyanates poisoning.
29. Toxic nephritis.

Rule 104 of the GFR, Rule 116 of the MFR and Rule 97 of the TNFR require that notice of poisoning or disease should be sent forthwith to the Chief Inspector, Certifying Surgeon, Medical Inspector of Factories and Administrative Medical Officer of ESIC. It should be in Form No. 22 (GFR).

4.2.3 Occupational Diseases under the W.C. Act and the ESI Act :

Sch. Ill u/s 3 of the Workman Compensation Act and u/s 52A of the Employees State Insurance Act rives a list of occupational diseases for which legal compensation is available. For detail this Schedule should be referred.

4.2.4 ILO List of Occupational Diseases:

ILO recommendation No. 194 of 2002 gives a list of occupational diseases as under:

(1) Diseases caused by chemical agents or their toxic compounds: - beryllium, cadmium, phosphorus, chromium, manganese, arsenic, mercury, lead, fluorine, carbon disulphide, halogen derivatives of aliphatic or aromatic hydrocarbons, benzene, nitro and amino derivatives of benzene, nitroglycerine, alcohols, glycols or ketones, asphyxiants, acrylonitrile, oxides of nitrogen, vanadium, antimony, hexane, mineral acids, pharmaceutical agents, thallium, osmium, selenium, copper, tin, zinc, ozone, phosgene, irritants like benzoquinone.

(2) Diseases caused by physical agents:- Noise, vibration, compressed air, ionizing radiations, heat radiations, ultra violet radiation, extreme temperatures (sunstroke, frostbite).

(3) Diseases caused by biological agents:-

(4) Diseases caused by target organ systems:- ' Respiratory diseases, Pneumoconioses, bronchopulmonary diseases, occupational asthma. Extrinsic allergic alveolitis, siderosis, chronic obstructive pulmonary diseases, lung diseases by aluminium, skin diseases, occupational vitiligo, musculo-skeletal disorders,

(5) Occupational Cancer caused by: Asbestos, Benzidine and its salts. Bis chloromomethyl ether. Chromium and its compound, coal tars, beta napththylamine, vinyl chloride. Benzene or its

homologues and its nitro & amino derivatives, ionizing radiation, tar, pitch, bitumen, mineral oil, anthrancene, etc. coke oven emissions, nickel compounds, wood dust.

(6) Miners' nystagmus.

4.3 Occupations involving Risk of Occupational Diseases and their Diagnostic Methods:

Following table gives a short synopsis of some occupational diseases, occupations involved and signs, symptoms and diagnosis.

Occupational Diseases Symptoms and Diagnosis				
	Diseases caused by	Occupational involved	Signs & Symptoms	Diagnosis / Indicator (see BEI if available)
Metals :				
1	Lead	Alloys, ammunition, lead batteries, lead lining, rubber, inks, lead burning, paints, ceramics, insecticides	Weakness, insomnia, motor weakness, muscle tenderness, impaired fertility, abdominal pain, lead line on gingival tissues	History, Pb in urine >65 µg/1 blood >30 µg/100 ml. Zinc protoporphyrin level>3 µg/gm HB
2	Phosphorous	Insecticides, fireworks, matchworks, explosives, detergents, chemicals	Irritation of respiratory tract, toothache, swelling of 'aw, facial disorder	History, teeth X-ray, pulmonary oedema in case of PCIs
3	Mercury	Acetaldehyde, acetylene, acetic acid, chlorine, thermometers, mercury vapour tubes, x-ray tubes, antifouling paint	Gingivitis, bitter taste in mouth, bluish line on gums, gastritis, bronchitis, nervous system effect	History, test for presence of tremors at rest or with movement In urine > 50 µg/ *l* In blood > 3 µg/ *l*
4	Manganese	Anti-knock agent in petrol, ceramics, electrode coating, glass, ink, mining, paints, pesticides, steel, alloy, tanning of leather	Chills, fever, headache, weakness, voice sinks, speech irregular, inability to run, cannot walk backwards	History, Mn in urine > 21µg/ *l* Faces > 60µg/ kg Hair > 4µg/ kg
5	Arsenic	Insecticides, fungicides, glass, metallurgy, pigment, rodent poison	Conjunctivitis, visual and nasal disturbances, cancer of skin, lung, larynx, gangrene of fingers	As in Urine > 1 mg/f Hair & nails may be useful
6	Chromium	Chromium plating, salts, leather tanning, photochemical processing, refractory bricks	Ulcers of nasal septum and fingers, irritation and conjunction pharynx and larynx, headache, jaundice, impaired liver function, lung cancer	Increased Cr in urine. Electrocardiogram, sputumgram stain and culture, white blood cell count and arterial blood gas analysis.
7	Beryllium	Alloys (as hardening agent) Nuclear reactors (as moderator), ceramics, fluorescent	Swollen mucous membranes, bleeding points, fissures and ulceration, weakness,	History, clinical tests. Be in lung tissue > 0.05 µg/100 gm is a strong indicator

		powders, lamps and tubes	weight loss, joint pain, breath shortness, skin injuries	
8	Cadmium	Alloys, (cadmium-nickel batteries, electroplating, engraving, soldering, paints for ceramics, glass, leather, plastics, rubber, inks. enamel	Chest tightness, nose irritation, cough, difficulty in breathing, vomiting, lung & kidney damage, dermatitis, anaemia, yellow teeth, metal fume fever, cancer and death	History Cd in blood > 5 μg/*l* indicates exposure
	Dusts :	Diseases of respiratory tract, caused by mineral dusts (silica, coal dust and asbestos; are called pneumoconiosis. They are silicosis and asbestosis. Fibres of sugar-cane cause bagassosis and those of cotton and textile cause Byssionosis.		
9	Silicosis	Sandblasting, cutting of quartzite, agate, gneiss, granite and slate. Manufacture - of glass, porcelain; pottery, mines, quarries, foundry and furnaces	Dyspnoea on exertion, cough, wheezing, chest illness, pulmonary TB or infection respiratory difficulty and death	Periodic radiological examination, egg-shell type calcification of lymph glands in 2-4% cases. Good chest X-ray with history. Should not be wrongly diagnosed as TB
10	Asbestosis	Asbestos mining and lining, insulation, safety garments, cement, fire blankets.	Chest pain, breathlessness, pleurisy, fever, leucocyfosis, cyanosis, finger.	History, chest radiograph, reduction in lung volume and forced vital capacity (FVC).
11	Bagassosis	Plywood	Breathing problem, cough, fever, chest pain, weakness, weight loss, sputum with cough or blood	History, gradual recovery after separating patient from contact of bagasse
12	Byssionosis	Plywood, cardboard, pressboards, paper, poultry feed, fertilizer, fuel, refractory bricks. Moist bagasse in sugar industry is not harmful. Dry bagasse is harmful	Breathing problem, cough, fever, chest pain, weakness, weight loss, sputum with cough or blood	History, gradual recovery after separating patient from contact of bagasse
13	Extrinsic allergic alveolitis.	Organic dust in animal and vegetable matter processing.	Dry cough, breathlessness, fever, muscular pain, sound in chest, asthma	History, sensitisation by antibodies, disturbances in lung function or positive inhalation provocation test.
	Gases, fumes, vapours etc. :			

14	Nitrous fumes	Nitration, use of nitric acid, neutralisation, bleaching of rayon.	Lung irritation, pulmonary oedema, vomiting, drowsiness, dizziness.	History, chest X-ray for basal scars, blood test for methaemoglobin, lung function affected.
15	Phosgene	Dyestuff, coal tar, urea isocyanates, acid chlorides, metallurgy, pharmaceuticals	Eye irritation, throat dryness or burning, vomiting, chest pain, cyanosis, skin or eye burns by splashes	History, electrocardiogram, sputumgram stain and culture
16	Carbon monoxide	Mines, tunnel work, boilers, blast furnaces, garages, industrial gases, metallurgy (as reducing agent), organic synthesis, metal carbonyls	Headache, tachypnoea, nausea, weakness, dizziness, cyanosis, syncope, hallucinations, mental damage. 50 ppm for 90 min cause aggravation of angina pectoris	History, cherry pink colour of blood, depression of ST segment of electrocardiogram, level of carboxyhaemoglobin > 40% collapse >25% headache, nausea
17	Iodine	Photographic film, iodine spray in salt	Irritation to eyes, nose and skin, lacrimation, blepharitis, rhinitis, stomatitis, chronic pharyngitis, headache and chesttightness	Electrocardiogram, sputumgram stain and culture, differential WBC count, arterial blood gas analysis
18	Fluorine	Electroplating, metal pickling, etching of glassware, artificial cryolite, insecticides, uranium compounds, aircraft piston engines, use a& HF acid	Laryngeal spasm, bronco spasm, pulmonary oedema, mild dyspepsia, exposure to mice showed liver and kidney damage	Fever, myalgias, lymphocytosis, radiographs of tibia and fibula show bony spicules, fluoride in urine and mother's milk
19	Chlorine	Chlor-alkali plant, use of Cl_2 gas, chlorination, bleaching process, metal fluxing, water cleaning, synthesis	Irritation of eyes and skin, substernal pain, vomiting with headache, damage, fall of BP arrest	Electrocardiogram, sputumgram stain and culture, differential WBC count and arterial blood gas analysis
20	Bromine	Manufacture or use of bromine, anti-knock compound for gasoline, bleaching agent, dyestuff, gold extraction, fuel additives, military gas	Irritation of eyes, nose, lungs and skin, inflammation of eye-lids, cough, vertigo, headache, nausea, diarrhoea, stomach pain, tongue & palate inflamed, chemical burns of lungs	Electrocardiogram, sputumgram stain and culture, differential WBC count and arterial blood gas analysis

21	Benzene	Chemical synthesis, use as solvent, reagent, fuel, detergents, pesticides, paint remover, shoemaking, producing other oro-anic chemicals	Narcotic action, CNC depression, irritation to skin and nose, euphoria, nausea, vertigo, damage to bonemarrow, blood-forming tissues, leukaemia	Phenol in urine (50 mg/g creatinine). For CNS syniptoms, neurologic examination. Complete blood count necessary
22	Hydrogen sulphide	Disinfectant, thiophene, inorganic sulphides, sulphuric acid, present in sewers, oil wells and petroleum products, natural decay of organic matter	Exposure of 500 ppm causes inflammation of nose, pharynx, bronchi & lungs, eye injury. 10 ppm for many days cause headache, weight loss, CNS disorders	History Periodical medical examination.
23	Acrylonitrile	Acrylic fibres, pesticide fumigant, organic synthesis	Eye irritation, sneezing, headache, vomiting, weakness, skin contact can cause blister and dermatitis, inhalation may cause death	History Measurement of blood pH, plasma bicarbonate and blood lactic acid.
	Chemical Compounds :			
24	Oragano phosphorous	Pesticides – parathion, malathion etc.	Fast absorption through inhalation, ingestion and skin contact, convulsions, vomiting, blurred vision, coma, BP increases and drops before death, oedema of lungs, loss of appetite, cyclical movement of eye-ball (nystagmus)	History 60% or more decrease in blood cholinesterase activity. Serum cholinesterase depressed in serious cases. Changes in blood picture (leukocyte count & formula) with a shift to the left. Increased secretion of saliva, 'tears and mucus
25	Carbon disulphide	Solvent used for alkali; cellulose, fats, oils, resin and waxes. Viscose rayon pesticides. oil extraction	Neurotoxic poison. ; Nausea, vomiting, , headache, excitation of nervous system, vision and sensory changes, chronic fatigue. Sexual, menstrual disorder & abortions in women	TTCA in urine 5 mg/g creatinine (at the end o) shift), blood and urine test iodineazide test of urine medical examinations
26	Halogen derivatives of aliphatic hydrocarbons viz. chloroform, chloromethane, vinyl chloride,	Solvents, refrigerant; anaesthetics, fumigant; plastic intermediate; gauge fluids	Lung irritants, eye and , skin injury, vinyl chloride , is carcinogen, effects on nervous system, headache, nausea, convulsions, paralysis,	History, for CN depression blood glucose rectal temperature to b noted and neurologicc examination. Live function test if liver

	CCl_4 etc.		affected speech, effect on kidneys and liver	suspected
27	Isocyanates	Polyurethane, PUF, paint Pesticides. varnishes	Irritation of skin, eye an mucous membrane respiratory system, asthmatic effect, rhinitis.	History, workers wit respiratory antecedents are more affected
28	Nitro/Amido toxic derivatives of benzene or it' homologues	Antioxidants, dyes explosives, insecticides pigments, plastics, resins rubber, solvents, textiles pharmaceuticals, fuel additives, elastomers	Cyanosis, anaemia, fatigue, nausea, chest pain, numbness, difficulty in breathing. Dermatitis due to DNCB. Liver damage due to 2-4 dinitro toluene. Some are carcinogens.	Urine & blood analysis. Haemoglobin should not be below 13 g/100 ml. Methamoglobin above 10% indicates . high exposure
29	Dinitro phenol, its homologue or salts	Dyes, explosives, wood its homologue preservative and chemical or salts production	Dermatitis. If ingested results in cataracts. Inhalation may damage liver, kidneys and induce fever. Skin contact makes the skin yellowish	History, skin pigmentation, presence of dinitro or aminonitro phenol in urine (Derrien's - Test)
30	Hydrofluoric acid	Fluorides, fluorocarbons, metal refining, pottery, etching glass	Irritation of eye, throat and nose. Skin burns. Oedema of lungs after 12 to 24 hours	History. Differential WBC count, electrocardiogram, sputumgram stain and culture
31	Fluoro-acetic acid, Sodium fluoroacetate & compounds	Chemical weapons, insecticides, pesticides, rat poison	Nausea, vomiting, stomach pain, low BP, convulsions after 6 hrs, effect on CNS and CVS	History, organically bound fluorine in body and increase of citrate in kidneys
32	Nitro-glycerine or nitroacid esters (e.g. nitro-cellulose)	Cardiovascular drugs, explosives	Headache, dullness, reduced BP, nausea, vomiting, weight loss, cyanosis, CNS disorders, hallucinations, heart problems, skin effect, ulcer under nails	History, Electrocardiogram if chest pain is reported
33	Methanol	Antifreeze mixtures, dewaxing preparations, dyes, formaldehyde, inks, paints, plastics, textile soaps, unshutterable glass, water proofing, as solvent	Enter through skin (may cause death), mouth and nose. If swallowed, can cause blindness, headache, vomiting, diled pupils, constant movement of eyeball (nystagmus), skin inury	History Disturbance in vision In urine – Methanol > 10 μg/ml formic acid - present

34	Acetone	Use as solvent. Production of acetic anhydride, chloroform, vitamin C. celluloid, explosives, iodoform, Used in dying, leather, lubrication, rubber, silk, varnish	Irritation to skin and mucous membrane. Difficulty in bread-ling. Damage to kidney and liver. Headache, blood changes, skin dryness & redness.	History, albumin, RBC & WBC in urine indicate damage to kidneys. High levels of urobilin and bilirubin indicate damage to liver.
35	Ketones	Use as solvent. Production of artificial silk, cosmetics, perfumes, plastics, explosives and pharmaceuticals	Narcotic Irritation to respiratory system, CNS affected	Medical examination of nerve, conduction velocity', CNS, eves, kidneys, liver and respiratory system
	Radiation :			
36	Radioactive substances and ionizing, radiation (X, A, B, G rays)	Radiography, gas chromatography, nuclear reactors, uranium mining, aerosol fire detectors, radioactive tracers, radium dial painting, Xray clinics	Exposure above I Gray results in nausea, vomiting, diarrhoea, intestinal symptoms, ulceration in mouth and throat, hair loss. Late effects leukaemia and cancer	Drop in lymphocyte count followed by slower and biphasic fall in granulocyte and platelet counts. Possible fall in RBC count. In intestine, ulceration of mucous membrane possible
37	Cataract by IR radiation	Arc processes, hot furnaces, lasers, molten lass. molten metal	Eye lens or capsule become opaque	History. Regular eye examination.
	Noise & Vibration :			
38	Hearing loss	High noise levels in loom shed, POY spinning dept., compressor room, pneumatic chipping or machining.	Ringing in ear, difficulty in hearing (e.g. ticking clock), sound perceived in abnormal manner	Audiometric examination and noise level measurement in work place
39	Decompression sickness	Work I compressed air or with vibrating tools or equipment, deep sea diving.	Dizziness, nausea, blood formation in ear drum, limb pain, skin effects, headache, coronary dysfunction, bone or joint pain.	Regular medical examination for respiratory and cardiovascular problems. Radiographs of shoulder, hip and knee joints.
	Bio-hazards :			
40	Diseases caused by biological agents (see part 7.2.2 also)	Contact with domestic, laboratory and other animals, laboratories, hospitals, dairy, forestry, meat or bone processing, poultry, tanneries	Anthrax (see part 9.4 also), dermatitis, inflammation, infection, jaundice, fever, upset stomach, muscular pain, headache, skin effect etc.	Redness or discoloration of skin, glandular tumour. In fungal infections swelling of fingers. herpes virus may cause

				meningitis.

Mode of causation may be many but the routes of entry in the body are inhalation, ingestion, skin contact and injection as explained in Part 6.6

Diagnostic Methods or tests are necessary to detect the disease. They are general as well as specific. Before selecting such test it is always useful to know the occupation of the worker, chemicals and other physical, biological agents involved in the occupation, work environment, work methods, protective wears used or not used, personal habits, family history and other possible combined causes which may be contributory to the cause of the disease, illness or poisoning. Some general or common diagnostic methods are given below and others in the table following.

Medical history and records.
Clinical examination.
Eye examination.
Biological examination of blood, urine, faeces (stools), breath, plasma, hair, nails, sweat, tissue, body organ etc.
Haematological indicators.
Spectrophotometric analysis.
Measurement of FEV 10.
Pathological tests.

Audiometry and measurement of noise level.
X-ray and radiographs.
Lung function and FVC test.
Lever function test.
Step test
Medical Examinations :
- Pre employment
- Pre placement
- Periodic
- Special
- Post sickness
- On request
- Retired workers

Cardiogram.
Sonography.

4.4 Evaluation of Injuries :

Evaluation of industrial injuries is required for the purpose of assessing the workmen compensation.

Injuries may be scheduled (Sch I & III, WC Act) or non-scheduled and it may result in (a) Death, (b) Permanent total disablement (c) Permanent partial disablement and (d) Temporary disablement, total or partial, as per section 4 of the WC Act.

For the Scheduled injuries, Sch. I gives percentage of loss of earning capacity for the injury type (b) and (c) mentioned above.

For non-scheduled injury, loss of earning capacity is to be assessed by a doctor as per section 4 (1) (c) (ii) of the WC Act, and while such assessment, the doctor has to give due regard to the percentages of loss of earning capacity in relation to different injuries specified in Sch. 1.

Loss of earning capacity depends on loss .of function which varies from part to part and its,, components are motion, strength and co-ordination.

In upper extremity, loss of each factor in the sholder has following estimation :

Motion	- 50%
Strength	- 30%
Co-ordination	- 40%
Disability of arm radical	- 50%
Disability of hand radical	- 30%
Disability of entire extremity	- 50%

In lower extremity, main function is weight bearing. The components of the function are motion, strength and weight bearing.

For fracture of the central .body part, the assessment is as under :

1.	Lumber region	-	50 to 100%
2.	Dorsal region	-	25 to 50%
3.	Cervical region	-	20 to 30%
4.	Spinous or traverse process	-	5 to 10%
5.	1 rib	-	No disability
6.	3 to 4 ribs	-	5 to 10% when there are after effects
7.	Sterrum	-	5 to 10%

Another assessments are as under :

EYE:

1	Loss of vision of both eyes	-	100%
2	Loss of vision of one eye	-	30%
3	30% loss of vision	-	9%
4	40% loss of vision	-	12%
5	50% loss of vision	-	15%

EAR:

1	Total loss of hearing	-	100%
2	Loss of hearing of one ear	-	15%
3	Loss of voice	-	25 to 50%

HEAD:

1	Headaches and giddiness	-	10 to 20%

See Part 7 for worked examples.
See Part 9 of Chapter 26 also.

4.5 Occupational Health Services & Medical Examinations:

4.5.1 Meaning and Functions of Occupational Health Services :

Occupational health service, is operated ' to achieve the statutory declared aims of occupational health by medical and technical measures. Its role is mainly preventive and to give first aid and emergency treatment. It is certainly useful in early detection of any occupational or non-occupational disease or any mal-adjustment of the man-job relationship.

Occupational health services include

1. Medical examinations : pre-employment, periodic and others.
2. Supervision of the working environment industrial hygiene, safety, job analysis and adaptation of the job to the worker in good working conditions.
3. Advice to management and workers.
4. Health education and training.
5. Health statistics.
6. Medical treatment-first aid, emergency and ambulatory treatment.
7. Health counselling-individual.
8. Nutrition
9. Family planning.
10. Research in occupational health.
11. Co-operation with other services in the undertaking.
12. Collaboration with external services.

Other purposes of industrial medical services are : (1) Identifying the hazards (2) Preventing or minimising the hazards (3) Curative treatment in case of exposure and (4) Determining the compensation for damages.

The services can be broadly divided into four phases : (1) Constructive medicine (2) Preventive medicine (3) Curative medicine (4) Educative medicine.

Constructive medicine includes - (1) Preplacement examinations (2) Periodic health examinations (3) Premature medical retirement.

Purpose of Periodic Health Examination arc : (1) To anticipate and prevent diseases (2) To detect potential illness and troubles in time and (3) To assist workers in maintaining normal health curve.

Periodic Health Check-up includes:

1. Complete clinical check-up.
2. X-ray of chest.
3. Vision testing.
4. Blood routine, sugar and cholesterol.
5. Urine routine.
6. ECG for workers above 40 years.
7. Indirect laryngoscopy for workers above 40 years.
8. Spirometry for workers employed in dusty, and smoky environment.
9. Audiometry for those, working in noisy environment.

See also Form XXII u/r 37 of the Insecticides Rules, 1971 in Part 4.2 of Chapter-28.

Industrial Medical Services in broad sense should be as follows:- -

Sr. No.	Facility	For No. of Workers.	Staff
1	First aid box (post)	Less that 150	Trained first aid attendant in

			each workshop.
2	First aid room of @ 35 m^2	Between 150 to 500	As above plus part time or full time nurse.
3	Medical Examination Room (Ambulance Room)	Between 500 to 1000 Trained first aid.	Trained first aid attendant for each shift plus nurse and Health Officer.
4	Factory Medical Centre	More than 1000	As above (3) plus one or more Health Officer, clerical and laboratory staff.
5	Factory polyclinic with different ambulatory services.	More than 10,000	As above (4) plus one or more specialists.
6	Factory hospital	Very large factory	Hospital staff.

4.5.2 Statutory Requirements :

Section 45 of the Factories Act and Rules there under require first aid and ambulance room facility with a qualified first- aider and prescribed medical and nursing staff readily available at factory premises. Section 41-C and Rule 68R to 68W(GFR) made there under have added following medical services at the work place for workers engaged in hazardous processes.

(1) Health Records (Rule 68R) :

Workers engaged in hazardous process shall be given their health/medical record under following conditions.

1. Once in every 6 months or immediately after his medical examination whichever is earlier.
2. If the worker shows signs/symptom? of any notifiable disease listed in the Third Schedule of the Factories Act (See Part 4.2.2).

3. If the worker leaves the employment.
4. If directed by the authority like the CIF Authorities under the W.C. Act, ESIC anc DGFASLI.

A copy or up-to-date health record including worker's exposure. X-ray film and medical diagnostic report may be given for reference to his medical practitioner. Form XXII u/r 37 of the Insecticides Rules, 1971 is one such statutory form. It is given in Part 4.2 of Chapter-28.

(2) Medical Examination & FMO (Rule 68T & U):

1. Workers employed in hazardous process shall be medically examined by a qualified medical practitioner called as factory medical office] (FMO). It is prescribed u/r 68U as under
   Full time FMO for workers > 200
   Part time FMO for workers 51 to 200.
   Retainer FMO for workers < 50
   1 FMO for more next 1000 workers or par

2. Pre-employment and six monthly periodical examinations are required.
3. Report of above examinations shall be in form No. 32.
4. First employment only after fitness certificate in form No. 33, Appeal regarding unfit, shall lie with the Certifying Surgeon (CS) whose opinion shall be final.

5. FMO will report to the CS, any abnormality/ unsuitability noticed by him. The CS will examine that worker and communicate his findings to the occupier within 30 days.
6. The CS on his own or on reference from the Inspector shall examine a worker employed in hazardous process. His opinion is final. His fees shall be paid by the occupier.
7. The worker suspended from employment on health ground may be re-employed in the same process after obtaining the fitness Certificate from the CS and after making its entry in form No. 32.
8. The worker required to undergo medical examination will not refuse it.

(3) Occupational Health Centres (OHC) (Rule 68U):

Type of OHC is prescribed for 3 classes of factories (1) Workers upto 50 (2) Workers 51 to 200 and (3) workers more than 200.

Size of OHC, equipment, nurse and staff, qualification and training of FMO, syllabus and course are also prescribed.

A certificate of Training in Industrial Health of minimum 3 months or a Diploma in Industrial Health is prescribed as necessary qualification for FMO, in addition to his MBBS degree.

Appointment of FMO shall be notified to the CIF within one month.

(4) Ambulance Van (Rule 68V) :

A hazardous factory employing more than 200 workers shall maintain in good condition, a suitably constructed ambulance van equipped with items prescribed. It should be manned with a full time driver cum mechanic and a helper trained in first-aid. -It will normally be stationed at or near the OHC.

A factory employing less than 200 workers may make arrangements for procuring such facility at short notice from a nearby hospital or other places to meet an emergency

5 STATUTORY PROVISIONS

Section 2(cb) of the Factories Act, 1948 defines "hazardous process" which would cause material impairment to the health or-pollution of the general environment. Sections 7A and 7B impose general duties on the occupier to ensure health and safety at work of all workers. The Section 36 speaks of the permissible limits of gas, fume, vapour or dust in any confined space. Section 41F prescribes for the permissible limits of exposure of chemicals and toxic substances (Second Schedule which is reproduced as Table-15 in. Chapter32). Section 41H creates duty to remove imminent danger to life or health. The whole Chapter IV-A makes the health and safety provisions more stringent. Section 87A creates power to prohibit employment on account of serious hazard. Section 89 requires notice of occupational diseases given in the Third Schedule wherein 29 diseases are named. This is reproduced in Part 4.2.2 of this Chapter. Section 91A provides for safety and occupational health surveys.

Rule 54 and 102 of the Gujarat Factories Rules, 1963 provide many safety provisions for dangerous operations which are more serious and cause occupational diseases and poisoning. Other rules for dust, fume, ventilation and temperature, disposal of waste and effluents, lighting, drinking water, latrines, urinals, spittoons, cleanliness, washing facilities, machine guarding, first-aid, canteen, dining hall, creche, notice of accident, poisoning and diseases are also for the health protection. Schedules for safety in solvent extraction plants, carbon disulphide plants, chemical works pottery, foundry, asbestos, electroplating and carcinogenic dye- intermediates have come into force from 152-95. They should be referred for safety. All schedules under rule 54 and 102 are most important and must be strictly followed. Form No. 37, Rule 12B requires work environment monitoring and record. See Reference No. 38 for more details. Rules 53, 61, 61 A to Q, 62 A toT, 63, 64, 95 and 102A of .the Tamil Nadu Factories Rules 1950 also provide similar details.

See Chapter-28 and its Part 5 for radiation health effects. Part 4 for toxic effects of insecticides. Part 10 for chemical health effects and Part 7 for health hazards to construction workers. These Acts and Rules provide for statutory control measures also.

6 INDIAN STANDARDS

Many IS are available on chemical, health and other safety areas which should be selected from the sectional lists of BIS (Bureau of Indian Standards) Handbook. IS on fire, chemical, textile, engineering, personal protection, plant design, ventilation, lighting etc. are already given in the respective chapters. Some more are mentioned below :

Air pollution-glossary of terms 4167, measurement methods of different exposures 5182 (20 parts), petroleum refiner,- 10179, 8636, 10044, fertiliser plants 8635, 9005, work environment monitoring (airborne contaminants) 9679, water pollution-textile industry 9508, electroplating industry 7453, fertiliser industry 9841, paper industry 5061, steel plant 8073, industrial effluents, sampling and test 2488, (5 parts) toxicity 6582, tolerance limits 2490 (9 parts), noise, ear protectors 9167, noise emitted by machines 4758, assessment of noise exposure 7194, noise reduction 3483, chemical sampling 8883, gas industry, glossary of terms 7062, ergonomic design 10224, safety colours and signs 9457, solid waste-glossary 9569, drinking water 10500, method of sampling and test for water used in industry 3025, industrial radiography 2596, 2478, 2598, radiation protection 6567, 7064.

7 WORKED EXAMPLES

(A) Determining Respirable Dust Concentration

Concentration if expressed as a mass (mg) per unit volume (m3) and shown in following equation:

C(mg/m3) = mass of sample (mg) / Volume of sampled air (m3)

The mass can be simply obtained from the gravimetric determination of the dust, after taking into account any difference with the blanks. The volume can be calculated using following equation

$V(m^3)$ = Flow Rate (L/min) x Duration of monitoring (mins) /1000

Example-1 :

Respirable dust sampling was conducted in Tobacco crushing unit over 8-hours by Industrial Hygienist. The calibration of the sampling train was checked before and after sampling and found to be 1.9 L/min. The mass of the sample on the filter was found to be 3 mg. What is the concentration of respirable dust?

Solve for concentration (mg/m^3) = mass of sample (mg) /volume of sampled air (m^3)

To determine volume (V)
= 1.9 L/min x 480 minutes / 1000
= 912 litres = 0.912 M^3

Concentration of resperable dust C

= 3.0 mg /0.912 m^3 = 3.3 mg/m^3

(B) Calculations For Crystalline Silica Exposures

Where the employee is exposed to combinations of silica dust (i.e., quartz, cristobalite, and tridymite), the additive effects of the mixture will be considered.

Example-2 :

Two consecutive samples from the same employee working in metal ferrous mine taken for a combined exposure to silica dusts have the following results shown below in Table. Calculate for Silica Exposure in terms of percentage of quartz. Permissible limits, TWA and Severity.

Results of Samples of Silica Dust

Sample	Sampling period (min)	Total volume (L)	Respirable weight (mg)	Respirable concentration (mg/m^3)	Laboratory results (%)
A	238	405	0.855	2.1	5.2 quartz 2.3 cristobalite ND tridymite
B	192	326	0.619	1.9	4.8 quartz 1.7 cristobalite ND tridymite
Total	430	731	1.474		
ND = Not detectable					

Calculation of the TWA from the sampling and analytical data:

Step 1. Calculate the percentage of quartz, cristobalite, and tridymite in the respirable particulate collected.

Quartz: 5.2 (0.855/1.474) + 4.8 (0.619/1.474)
= 3.0 + 2.0 + 5.0%
Cristobalite : 2.3 (0.855 / 1.474) + 1.7 (0.169 / 1.474)
= 1.3 + 0.7 = 2.0%

3Step 2. Calculate the Permissible Exposure Limit (PEL) for the mixture.

$$PEL_{mixture} = \frac{10\ mg/m^3}{\%\ quartz\ + 2\ (\%\ cristobalite)\ + 2(\%\ tridymite)\ + 2}$$

= 10 / [5.0 + 2 (2.0) + 2 (0) + 2] = 10 / 11.0
= 0.91 mg/m^3

Step 3. Calculate the employee's exposure. Exposure (Sample wt. A + Sample wt. B)/ Total volume
= (0.855 +0.619)/0.731 =
= 2.0 mg/m^3

Step 4. Adjust (where necessary) for less than 8-hour sampling period.

$TWA = (2.0\ mg/m^3)[(430\ min)/(480\ min)]$
$= 1.8 mg/m^3$

Step 5. Calculate the severity of the exposure.
$(1.8\ mg/m^3)/(0.91\ mg/m^3) = 2.0$

(C) When two or more hazardous substances have a similar toxicological effect

When two or more hazardous substances have a similar toxicological effect on the same target organ or system, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, different substances should be considered as additive where the health effect and target organ or system is the same.

That is, if the sum of: $C_1/T_1 + C_2/T_2 + ...Cn / Tn = 1$

Where, C1 indicates the observed atmospheric concentration and T, is the corresponding threshold limit)

Example-3

Air contains 400 ppm of acetone (TLV,750 ppm),150 ppm of sec-butyl acetate (TLV,200 ppm) and 100 ppm of methyl ethyl ketone (TLV,200 ppm).

400/750 + 150/200 + 100/200
= 0.53 + 0.75 + 0.5
= 1.78

Threshold limit is exceeded.

(D) Calculation for Workmen Compensation:

Compensation for occupational diseases is payable u/s 3 of the Workmen's Compensation Act, 1923. Subsections (2 to 4) provide as under :

1. Contracting of the disease peculiar to the employment and specified in Part A, B & C of Schedule III (mentioned in foregoing part 7.2.4) is to be considered as an injury h/ accident arisen out of and in the course of the employment.
2. For Part A diseases, compensation is payable irrespective of any length of service as the incidence rate or possibility of such diseases is high and very obvious.
3. For Part B diseases, compensation is payable provided a service of 6 months is completed, as these diseases are very specific to certain chemicals and their incidence rate is slightly lower than that of Part A diseases.
4. For Part C diseases, compensation is payable, irrespective of length of service and even if the affected worker has worked under one or more employers, as these are lung diseases and their effect is delayed i.e. visible after 5 to 10 years of service.
5. Compensation is payable for Part B & C diseases even after the cessation of the service.
6. For Part C diseases and for working under more than one employer, all the employers are liable to pay compensation in proportions decided by the W.C. Commissioner.

7. For any other disease, if it is directly attributable to a specific injury by accident arising out of and in the course of employment, the compensation is payable.
8. Compensation is not payable if any suit for damages is filed in the court or a suit for damages shall not be maintainable if a claim for compensation is filed before the W.C. Commissioner, or if any agreement is made between the workman and his employer to pay in accordance with the WC Act.
9. The doctor shall refer Schedule I while 'assessing percentage loss of earning capacity.
10. The maximum period of half-monthly payment for temporary disablement is 5 years, and wage limit of Rs. 4000 is not applicable in this case.

Examples :

Section 4 and Schedule I, III and IV are to be seen simultaneously. Monthly wage limit is Rs. 4000.

For example, if death occurs due to any disease mentioned in Sch. Ill, payment should be as per Section 4 (1) (a).

Example 4 :

A worker of 24 years (completed) and drawing monthly wages of Rs. 3800, dies due to any disease mentioned in Part A or C or any disease in Part B if his service is of more than 6 months, amount of compensation shall be

= 0.50x3800 x 218.47 (Age factor)
= 1900 x 218.47
= Rs. 4,15,093 or Rs. 8,000
whichever is more.

Note : If monthly wages are more than Rs. 4000 per month, consider Rs. 4000/- only for the purpose of calculation. Age factor is derived from Schedule IV based on completed years of age,

Example .5 :

A worker gets any of the permanent total disablement mentioned in Part I of Sch. I, due to occupational disease in Part III, and his age and monthly wages are 48 and Rs. 5600 respectively. Compensation will be-

= 0.60 x 4000 x 159.80
= 2400 x 159.80
= Rs. 3,83,520 or Rs. 90000
whichever is more. Example 6 :

A worker loses partial vision of one eye (item 26A, part II, Sch. 1) due to occupational cataract by infrared radiation (item II, Part B, Sch. Ill) at the completed age of 40 with monthly wages Rs. 6500. Compensation shall be -

= 0.10 x 4000 x 184.17
= 400 x 184.17
= Rs. 73668.

Example 7 :

A worker suffering from silicosis (e.g. any lung disease) - injury not specified in Sch. I, but certified by a doctor as '80% loss of earning capacity (permanent partial disablement)' at his age of 58 and monthly wages Rs. 9600, his compensation shall be = 0.80 x 4000 x 124.70 = 3200 x 124.70 = Rs. 3,99,040.

Example 8 :

A worker's whole middle finger is amputated (item 31, Part II, Sch. 1) due to chrome ulceration and his lung damaged by 30% permanent partial disablement as assessed by the doctor, due to exposure to chromium vapours, and his age and monthly wages being 38 and Rs. 5600 respectively, his compensation shall be

(1) For finger damage
= 0.12x 4000 x 189.56
= 480 x 189.56
= Rs. 90988.80

(2) For lung damage
= 0.30 x 4000 x 189.56
= 1200 x 189.56
= Rs. 2,27,472

Total Rs. 90988.80 + 227472.00
= Rs. 3,18,460.80

Comparing with permanent total disablement [Sec 4 (1) (C), Explanation - 1]
= 0.60 x 4000 x 189.56
= 2400 x 189.56
= Rs. 4,54,944 or Rs. 90000

whichever is more.

As amount Rs. 318460.80 does not exceed Rs. 454944, total compensation payable in this case is Rs. 318460.80.

Example 9 :

A worker worked in three sugar mills in a continuous period of 16 years and it was detected that he was suffering from bagassosis due to sugarcane dust. This was found at his age of 45 and monthly wages Rs. 7800. The lung damage (permanent partial disablement) assessed by a doctor is 50%. Calculate the compensation payable by each of the three employers.

Compensation

= 0.50 x 4000 x 169.44
= 2000 x 169.44
= Rs. 338880

As per Section (2-A), each employer may pay Rs. 338880/3 = Rs. 112960 to the worker, or in the proportion decided by the WC Commissioner depending on the facts of his case. The employer in whose sugar mill suppose the dust concentration was higher or for longer duration, may be directed by the Court to pay more proportion of the total amount.

Example 10 :

A worker while handling organo phosphorous compound, undergoes toxic effect and remains absent for 3 months as per medical finding of this cause and advice. To what compensation he is entitled for this temporary disablement? He is drawing Rs. 4500 per month

As per Section 4 (1) (d), he is entitled to a half monthly payment of 25% of his monthly wages i.e. 0.25 x 4500 = Rs.ll25 from the 16th day from the date of disablement.

Here ceiling of Rs. 4000 per month is not applicable. It is applicable to death or permanent total disablement only [Explanation II to Sec 4 (1)1.

EXERCISE

1. State, Explain, Discuss:

1. Define and explain the meaning of Industrial Hygiene.
2. How work of Industrial hygienist. Safety Officer and Occupational Health Specialist is useful to each other?
3. Classification of occupational health hazards.
4. Adverse effects of health hazards and their control measures.
5. Biological effects of ionizing radiation and their controls.
6. What is radiation accident? State its control measures.
7. Classification of air borne contaminants.
8. 'What is particulate matter? Explain their types and how they are generated.
9. Routes of entry of toxic material into human body.
10. Toxicity, Toxicology and its main elements.
11. Purpose and Types of Air Sampling.
12. Main parts of any sampling instrument.
13. Biological Monitoring and its Determinants.
14. Three level control measures for health hazards.
15. Types of Engineering controls for health hazards.
16. Types of Medical controls and Administrative controls for health hazards.
17. Physiology and work physiology.
18. Muscular work, physiological factors and physiological reactions.
19. Assessment of workload.
20. Nutrition, Diets, Physical fitness and their relationship.
21. What are Ergonomics and its usefulness for safety?
22. Examples of application of ergonomics.
23. Safe use of muscle and lever systems in load carrying.
24. Physiological problems with load carrying.
25. Ergonomic Office furniture and Utility tools.
26. Types of Dusts and their effects.
27. Different dust control methods.
28. Preventive measures for occupational dermatitis.
29. Preventive measures for occupational cancers.
30. Statutory provisions of Medical Examinations for workers.

2. Write Short Notes on :

1. Branches of Occupational health.
2. Types and limits of atomic radiation.
3. Health Physics. OR Application of ionizing radiation.
4. Decontamination of ionizing radiation.
5. Uses of Radio and Microwaves and their Safety measures.
6. Radar, its Hazards and Control measures.
7. Laser beam, its Hazards and Control measures.
8. Types of gases and vapors.
9. Factors and Types of Toxic effects.
10. Dose response relationship.
11. Recognition and Evaluation of health hazards.
12. Air sampling methods
13. Air sampling strategies.
14. Air sampling devices.
15. Samples Analysis methods.
16. Examples of Direct and Indirect biological monitoring.
17. Air quality and Stack monitoring.
18. Air pollution control systems.
19. Cardiac Cycle.
20. Muscle contraction.
21. Consequence of Muscular work.
22. Criteria for fixing limits of manual lifting and carrying.
23. Aerobic work capacity arid factors affecting if.
24. Physiological safe limit for continuous work.
25. Tests for physical fitness.
26. Fatigue and rest allowances.
27. Functions of Nutrients.
28. Factors affecting work performance.
29. Constituents of Ergonomics.
30. Areas where Ergoftomic design is most useful.
31. Design of Tools in relation to body postures.
32. Concept of Percentiles in ergonomics.
33. Ergonomic design of Machine Controls and Displays.
34. Location of machine controls and their sequence of operation.
35. Natural expectation of control movement.
36. Inadvertent activation.
37. Ergonomic Foot Controls.
38. .Displays and Light signals.
39. Dusts and Lung diseases.
40. Occupational dermatitis OR Occupational Cancer.
41. Diagnostic methods for occupational
42. Types .of occupational health services OR Types of periodic health check-up.
43. Industrial Medical services.
44. Health Records.
45. Occupational Health Centre OR Ambulance Van.

3. Explain the Difference between :

1. Industrial Hygiene and Occupational Health.

2. Occupational health and Public health.
3. Occupational and Non-occupational hazards.
4. Environmental and Non-environmental Occupational hazards.
5. Health effects of Noise and Vibration.
6. Ionizing and Non-ionizing radiation.
7. Infrared and Ultraviolet Radiation.
8. Gases and Vapors OR Gases and Particulate Matters.
9. Corrosive and Explosive OR Mutagen and Teratogen.
10. Ignitable, Flammable and Extremely Flammable.
11. Ceiling limit and Exposure limit.
12. TLV and STEL OR STEL and IDLH.
13. LC50 and LD50 OR Neurotoxin and Hepatotoxin.
14. TLV and BEI OR TLV and Excursion Limit.
15. Qualitative and Quantitative Exposure Assessment.
16. Direct and Indirect Biological monitoring OR Area and Personal Monitoring.
17. Grab sampling and Integrated sampling.
18. Thermal incineration and Venturi Scrubber.
19. Medical Controls and Administrative Controls.
20. Anthropometry and Biomechanics.
21. Respiratory Quotient and Respiratory pigment.
22. Light, Moderate and Heavy work.
23. Skin irritants and Skin sensitizers.
24. Silicosis and Asbestosis.
25. Bagassosis and Byssionossis.

4. Comment of the following explaining whether it is True or False.

1. If industrial hygiene practices are implemented, there will be less work for occupational health specialist.
2. Ionizing radiation is less hazardous than non-ionizing radiation.
3. Vapor particles are smaller than gas particles.
4. TWA,. STEL and Ceiling limit - all are TLVs.
5. Material having LD50 200 is more toxic than that having LD50 20.
6. Fibrosis is caused by hard metals and Siderosis by Iron.
7. CO poisoning is not a notifiable disease.
8. Arsenic may cause lung disease while Vinyl chloride may cause liver disease.
9. Beryllium affects bone while lead affect kidney.
10. Benzene affects prostable while Cadmium affects mouth.

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CHAPTER – 25

Personal Protective Equipment

THEME

1. NEED AND LIMITATION

For any accident prevention work, engineering control is the best control, and aid of personal protective equipment should be the last resort or a supplementary control. Nevertheless importance of personal protective equipment (PPE in short) is not less, its scope and utility have been tremendously increased during last few years and wide varieties of such equipment are available in the market. This requires proper selection of quality and utility for specific purpose. The problem is not of the availability, but is of its use by workers on the shop floors. Particularly in a country like ours where the majority of workers are illiterate, not safety conscious and not trained to wear such equipment, the problem becomes more acute mostly in small and medium scale factories.

The statistics of accidents exclusively due to non-use, misuse or defects of PPE is not available as there is no such distinct accident classification. But if we consider causes No. 7 to 15 in Table 5.20, Chapter5, it can be said that in 1997, out of total 246 fatal accidents due to these causes, at least 160 i.e. 65.04% could have been prevented by the proper use of PPE. Total of causation No. 120 to 131 in the last row of Table 5.22, Chapter-5, gives 65.89% (10334 out of 15683 accidents during 1994) fatal and non-fatal accidents. Of this at least half i.e. 33% of total accidents could have been prevented by the effective use of PPE. The conclusion is that @ 30 to 40% of total accidents can be prevented or controlled by the proper use of personal protective equipment. This figure is not small and highlights the need of PPE.

Most of the minor accidents are due to material handling, striking against objects, hurt by falling bodies, falling or slipping, injury by hot substances or chemicals and neglecting PPE. Such accidents can certainly be reduced to great extent by the effective use of appropriate PPE.

The PPE provides good defence against hazards of toxic exposure, oxygen deficiency, dusting, chemical splashes, steam, water and liquids, flying particles, hot substances, radiation, sharp edges, welding, cutting, grinding, striking against and stepping over objects, glare, personal falls and injury due to falling bodies, noise, scrap cleaning, material handling, opening of pipe lines or any hazardous work, electric shocks, burns and fire fighting. Many fatal accidents are caused due to these reasons and use of appropriate ' PPE can prevent or lessen many of them.

Limitation of the protection by PPE should be well understood. Respirators have limited use for the concentration and time mentioned by the manufacturer. They cannot be used in higher concentration for longer time. In heavy concentration, only self breathing apparatus (SBA) is recommended and that too for a limited time. Instead of providing hood and suction on flying particles, there is no meaning of giving respirator to a worker. Instead of providing guard on a grinding wheel, it is meaningless to provide eye protection to workers. Instead of sealing leakage of gas or dust or allowing to continue, it is unsafe to advise the worker to use gas mask. Similarly instead of trying to reduce pollution, it is of no use to tell the workers to use PPE only. It is always safer to improve the working conditions by engineering controls first. Then only the use of PPE may be recommended. It is the second line of defence.

PPE is a second line of defence. The first line is to eliminate or minimise the workplace hazards. PPE cannot eliminate the hazard, it can help eliminate an injury or reduce its severity.

I remember a few fatal accidents from my investigation where I was of the opinion that besides engineering controls, PPE could have prevented such accidents. When an engineering control fails or becomes ineffective, what is the protection? Then this line of defence (i.e. PPE) comes to help and protect in most of the cases. In one case a worker died due to phosphine exposure and in another case due to chloroform vapour in a tank. In third case due to a splash of 2-4 dichlorophenol a worker died within 15 minutes. In still other case, a worker died due to pesticide exposure in delayed effect. All four were young workers and died due to these toxic chemicals. If they would have worn appropriate PPE, they could have been survived. This shows the significance of need of PPE. Though PPE cannot eliminate the hazard (like engineering control) it can certainly protect from it.

The need of PPE can be well judged from:

1. Visual and foreseeable hazards.
2. Accident experiences.
3. Report of the safety committee/ representatives.
4. Safety audits, surveys, sampling, job safety analysis and risk assessment.
5. Legal requirements and remarks of the authorities.
6. Record of the medical department.

The need of PPE exists because

1. Chances of failure of engineering controls, materials, process, equipment and safety devices cannot be denied and in those circumstances, the PPE can act .as a barrier between the man and hazard and to save from the injury.
2. There are certain operations or accidental situations where engineering controls are less possible and PPE becomes necessary. For repair or maintenance or to enter into toxic or oxygen

deficient atmosphere, or while working at height or doing jobs like welding, cutting, grinding, chipping, PPE gives good protection.

3. It effectively avoids the contact of dangerous substances, noise, vibration and radiation.
4. It protects from atmospheric contaminants.
5. It is a legal as well as moral duty to provide suitable PPE.

2 STATUTORY PROVISIONS

No specific personal protective equipment is named by the Factories Act, but working conditions mentioned in sections 14, 30, 33, 35, 36, 37, 38, 87, III and 114 are such that free of charge PPE should be provided by the occupier for the protection from hazards due to dust, fume, gas, vapour, flying particles, glare, revolving machinery, hot or dangerous contents, entry in confined space, explosive or flammable atmosphere, fire, dangerous operations and hazardous processes. Rules prescribed under above sections provide further details. 27 schedules of Rule 102 of the Gujarat Factories Rules indicate need of PPE at many places. Duty is cast upon the workers not to wilfully neglect to make use of such equipment and not to interfere with or misuse them. ' Model Rule 58 u/ s 35 and Model Rule 95 u/s 87 also prescribe PPE for specific processes.

Rule 68B, GFR states that the PPE shall conform to the Indian Standards. OSHA standards prescribe tremendous details for PPE. Noise induced hearing loss is an occupational disease under the 3rd Schedule of the Factories Act. Schedule 23 u/r 102, GFR requires noise reduction below 90 dBA or to provide ear protectors to workers and their auditory examination by a doctor. Sch. 27 required protection against cotton dust.

3 INDIAN AND OTHER STANDARDS

Some IS on PPE are as under:

Head - Helmets, industrial safety 2925, for two wheelers 4151, non-metal for police force 9562, wooden head- form for testing of helmets 7692, miner's cap lamps 5679 3

Eyes and Face- Guide for selection of eye, face and ear protection 8520, 8521, maintenance and care 8940, for welding 1179, methods of test 7524 (Parti & 2), eye protectors, filters 5983, safety glass 2553, eye and face showers 10592

Ears - Guide for selection 8520, ear protectors 9167, earmuffs, method for measurement 6229

Hands - Guide for selection 8807, Gauntlets and mittens, leather 2573, gloves - safety 6994, rubber - electrical 4770, surgical 4148, postmortem 4149

Feet & Legs - Footwear, selection 6519,10667, Ankle boots for general purposes 583, boots and shoes safety, leather 1989, leather for firemen 4128, rubber - canvas for miners 3976, 10665, gaiters, protective 2472, knee boots, rubber 3736, 3738, leather for leg guard 3946, toe caps, steel for footwear 5852, boots for oilfield workmen 9885 (Part I & 2), footwear for steel plants 10348, for mines and heavy metal industry 13295, safety shoes for women workers in mines and steel plants 11225, footwear with direct moulding sole 11226, rubber footwear 11264, PVC boots 12254, chemical resistant 13292, 13695, PVC boots, oils and fats resistant 13038, code of practice for manufacture 13295, lined antistatic rubber footwear 13575, wooden, heavy duty 5520, rubber lined boots 5557, conducting 13996

Body - Guide for selection of body protection 8519, aprons - rubberised acid and alkali resistant 4501, rubber for hospital use 6407, leadrubber, X-ray protective 7352, Clothing - fire resistant 4355, fire (flame) resistant suit 7612, leather 6153, sheath rubber 3701, fabrics, PVC coated for foul weather 3322, belt and strap, leather, lineman's safety 3521, material (nylon webbing) for aircraft safety belts 8947, maintenance and care of safety clothing 8990, evaluation of whole body vibration 13276 (Part I to 3), mechanical vibration and shock affecting man 13281

Lungs - Glossary of terms relating to respiratory protective devices 8347, selection, use and maintenance of respiratory, protective devices 9623, colour identification of air purifying canisters and cartridges 8318, mouth-piece assemblies 14170, full face mask 14166, threads for face pieces 14138. Respirators - chemical cartridge 8522, canister type (gas mask) 8523, filter type for particulate matter 9473, CO filter 9563, bag type, positive pressure, manually operated 6194.

Breathing apparatus 10245 -
Part 1 : Closed circuit (0, cylinder).
Part 2 : Open circuit.
Part 3 : Fresh air line.
Part 4 : Escape type, short duration, self contained.

Breathing apparatus for fire brigade self contained 1910, Resuscitators for use with humans 13366, life jackets 6685

4 SELECTION AND CLASSIFICATION

Once it is decided that PPE is needed,

1. Select proper type of equipment (IS mentioned in Part 3 should be referred) and then
2. Make it sure that the supervisor sees to it that the worker uses and maintains-it correctly. Proper selection, training and use of PPE are essential.

Factors of selection or requisite characteristics of PPE are :

1. It should give adequate protection against the nature, severity and type of hazard.
2. It should be of minimum weight, should give minimum discomfort with protective efficiency.
3. Attachment to the body should be flexible yet effective.
4. The wearer should not be restricted in movement" or perceptions required for the job.
5. It should be durable and attractive.
6. It should not cause any hazard through its material, design, defect, use or failure.
7. It should conform Indian Standards and tests required
8. It should be easy to clean, repair and maintain. The parts, piece and service should be easily available.

If all above criteria are not available effort should be made to get maximum of them.

Classification of PPE for selection and understanding is given below and also in Table 25.1:

- PPE
- Respiratory (Breathing)
  - Air purifying
    - Chemical Filters
      - Chemical gas mask, Chemical cartridge, Self rescue filters
    - Mechanical Filters
      - Dust or Nuisance filters, Micro filters
    - Combination of Chemical and Mechanical Filters
  - Supplied air
    - Air-lined
      - Airline respirator, Suction hosemask, Pressure hosemask or hood, Air Supplied Suits
    - Self-contained
      - Damage type (open-circuit)
        - Compressed air, Compressed oxygen
      - Re-circulating type (closed-circuit)
        - Compressed oxygen, Regenerated oxygen
- Non-respiratory

For Protection of Head, Eyes, Ears, Face, Hands, Arms, Feet, Legs and Body. Special work clothing- e.g. asbestos, aluminised, leather and wool garments, lead clothing, disposal clothing etc.

Table 25.1 Selection and Classification of PPE according to the body part and hazards :

Body-Part	Hazard	PPE necessary
Head	Falling objects, shock, chemical spurting	Safety helmet, hard hats, safety caps, headgear
Eye	Chemical splash, dust, flying, particles, gas, welding radiation.	Spectacles, lenses and goggles for chemical, welding, grinding, furnace, dust etc.
Ear	High level noise (> 90 dB)	Earmuffs, plugs, inserts
Nose	Dust, toxic gases	Dust mask, cloth mask, rubber mask, fume mask, respirators for dust, gas and vapour, rescuer plus pressure suit, breathing apparatus (O_2 or Air), Canister gas masks, air line respirators, chemical / mechanical filters.
Face	Chemical splash, flying objects, hot substance.	Face shield, welding screen, furnace mask, face guard.
Hand	Hot substance, acid, alkali, pigments, chemicals, handling, cut, sharp edge.	Hand gloves of rubber, PVC, hosiery cotton, leather, asbestos, canvas, fibre glass, electrical rubber gloves, surgical gloves, arm sleeves.
Body	Chemicals splashes, hot substance, fire,handling,	Aprons, coats and pants, pressure suit, suits of rubber, PVC etc.
Foot / Leg	Striking against objects, chemicals falling bodies	Leather or rubber sole shoes, steel toe-boots, antiskid sole shoes, ammunition boots, gumboots, leg sleeves.
Overall	Falling from heights, hurt by falling bodies, chemicals	Safety belts, pole strap belt, nylon safety harness, all purpose safety harness belt, vertical lift safety harness, Boatswain's chair, rope ladders, nets, safety hooks.

Selection and classification of Respiratory equipment based on type of hazard :

- PPE
- Respiratory (Breathing)
  - Air purifying
    - Chemical Filters
      - Chemical gas mask, Chemical cartridge, Self rescue filters
    - Mechanical Filters
      - Dust or Nuisance filters, Micro filters
    - Combination of Chemical and Mechanical Filters
  - Supplied air
    - Air-lined
      - Airline respirator, Suction hosemask, Pressure hosemask or hood, Air Supplied Suits
    - Self-contained
      - Damage type (open-circuit)
        - Compressed air, Compressed oxygen
      - Re-circulating type (closed-circuit)
        - Compressed oxygen, Regenerated oxygen
- Non-respiratory

1. Self contained Breathing Apparatus
2. Hose Mask and Blower with escape provision

Selection of Material of Construction of PPE is given in Table 25.2 :

Table 25.2 : Selection of Material of Construction for PPF.

No.	Material	For the protection from
1	Metal	Flying particles, falling body, sharp edge, abrasion.
2	Fibre metal	Sparks, falling body, flying particles, sharp edge, abrasion, machinery
3	Metal screen	Sharp edge & abrasion
4	Plastic, PVC	Hot liquid, moisture, water, petroleum product, acid, alkali, spark, falling body, flying particles, electric shock, sharp, edge, abrasion, skin protection
5	Rubber	Hot liquid, moisture, water, acid, alkali, electric shock, machinery, skin protection
6	Conductive rubber	Explosive substance
7	Chrome leather	Hot substance, flying, particles sharp edge, abrasion, sparks
8	Canvas	Flying particles, sharp edge, abrasion, machinery
9	Asbestos	Heat, hot substance, sparks
10	Acid proof fabric	Acid & alkali
11	Reflective fabric	Hot liquid
12	Flameproof duck	Heat, hot substance, sparks, chemicals, flying particles, machinery
13	Cotton wool	Heat, sparks, machinery, skin protection
14	Cotton canvas	Sharp edge & abrasion
15	Steel hoe boot	Falling body, striking
16	Non-skis shoes	Moisture, slippery surface
17	Wooden sole boot or scandal	Heat, hot substance, moisture, water, acid, alkali, slippery surface, sharp edge, abrasion.
18	Soft silicon rubber or plastic	Moulded type ear plug
19	Plastic goggles with hydrophilic coating	To prevent fogging
20	Wirescreen lenses (face shield)	Heavy fog or dampness
21	Laser safety goggles (Antilaser eyeshield)	Laser beams
22	Aluminised welding helmet	Infrared rays and to reduce heat effects
23	Polarising lenses (filtershade lenses)	To prevent glare
24	Steel, reinforced plastic & hard rubber	Safety toe boot for foot protection
25	Boot with non-ferrous coating and conductive sole	Static charge, friction sparks, and to reduce fire and explosion possibility
26	Congress or gaiter type shoes	Work with hot metal in foundry, quick removable shoes without lash
27	Non-conductive or insulating (non-metallic shoes)	Electric work
28	Flexible metal reinforced stole or inner sole	Construction work and cold metal work with possibility of foot injury
29	Plastic shoe cover or cap	Pharmaceutical factory needing higher

		product safety.
30	Specially made asbestos clothing	To work with hot metal upto 1650 ^oC
31	Aluminised asbestos or glass fibre and wool lining	To work near a furnace at temperature upto 540 ^oC for fire fighting. Such proximity clothing should to be utilized to enter into the fire. they are for working from a distance.
32	Flameproof or flame resistant cloths – THPC, Nomex or Modaphrilic fabrics	Fireproof cloths to work in the fire flames
33	Cushion pads or padded duck	To carry heavy or sharp edged load on shoulder or back.
34	Apron of padded leather, fabric, plastic, hard fibre or metal	For protection of abdomen or middle body parts.
35	Thermal net cotton go quilted material (decron or nylon)	To work in cold weather (unsuitable to work in hot or fire).
36	High visibility and night hazard clothing	For construction and maintenance Police and Fire brigade and Traffic hazards
37	Disposable clothing (Plastic or reinforced paper)	In less radioactive work or drug or electronic industry
38	Leaded clothing (lead glass fibre, leaded rubber, leaded plastic)	Laboratory work, protection against X and Gamma rays
39	Electromagnetic radiation suit	Radar field
40	Conductive clothing	For linemen to work at extra high voltage. Such clothing keeps the linemen at the proper potential.

5 NON RESPIRATORY EQUIPMENT

See Fig. 25.1 for non respiratory PPE.

5.1 Head and Hair Protection :

Head protectors are hard hats, caps and helmets made of aluminium, PVC fibre glass, laminated plastic or vulcanised fibre. They may be fitted with brackets for fixing welding masks, protective face screen or a lamp. The hats and caps are provided with replaceable harness which provides sufficient clearance between the top of the head and shell. Selection is as follows:

	Material	Protects against
1	Asbestos	Sparks, hot materials, heat
2	Plastic rubber	Hot liquids, moisture, acids, alkalis, electric shocks, dermatitis
3	Cotton wool	Sparks and heat, dermatitis, machinery
4	Metal	Falling objects, flying particles, cuts, abrasions.
5	Plastic	Sparks, falling objects, flying particles electric shock, cuts, abrasions.

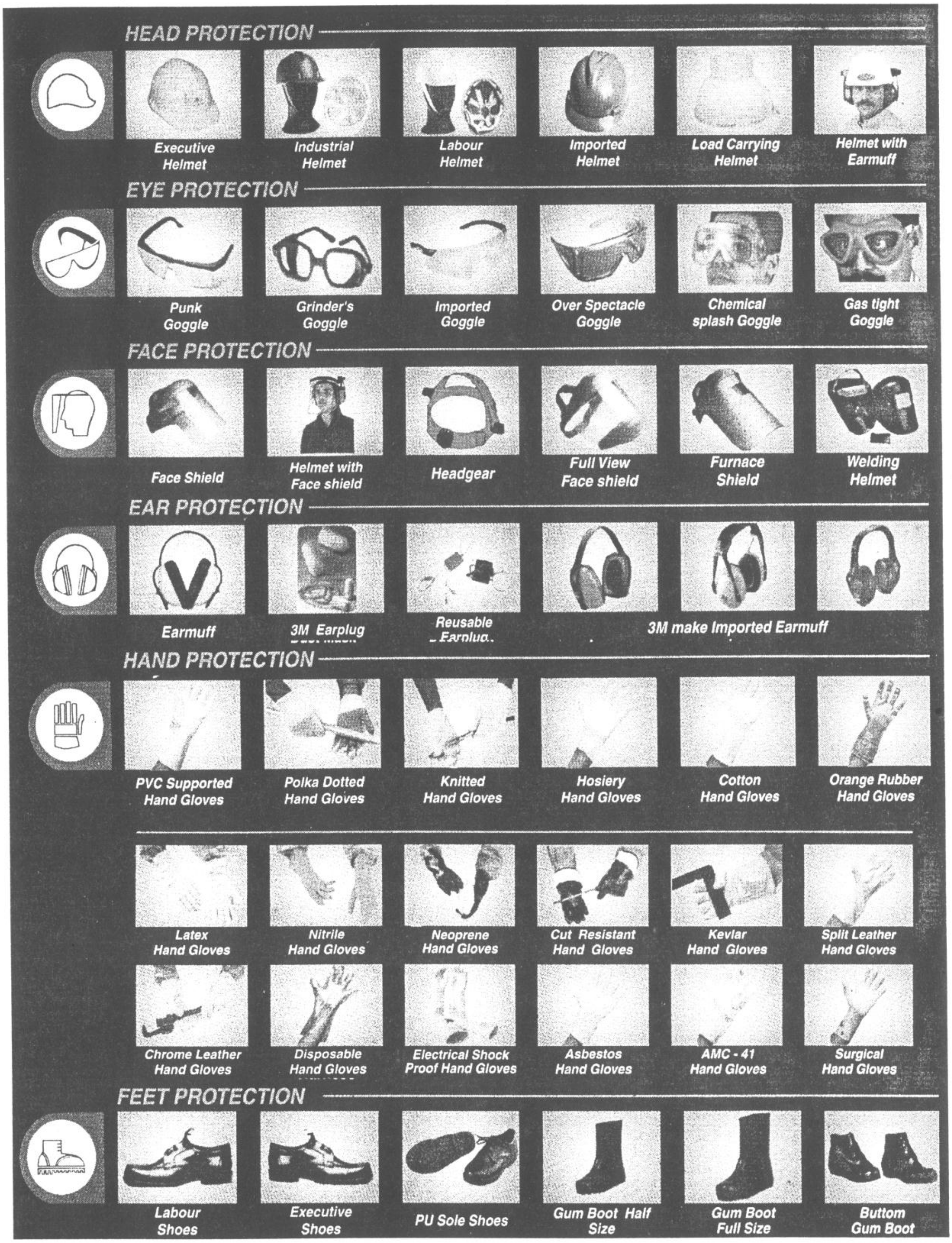


Fig. 25.1 Non Respiretory PPE

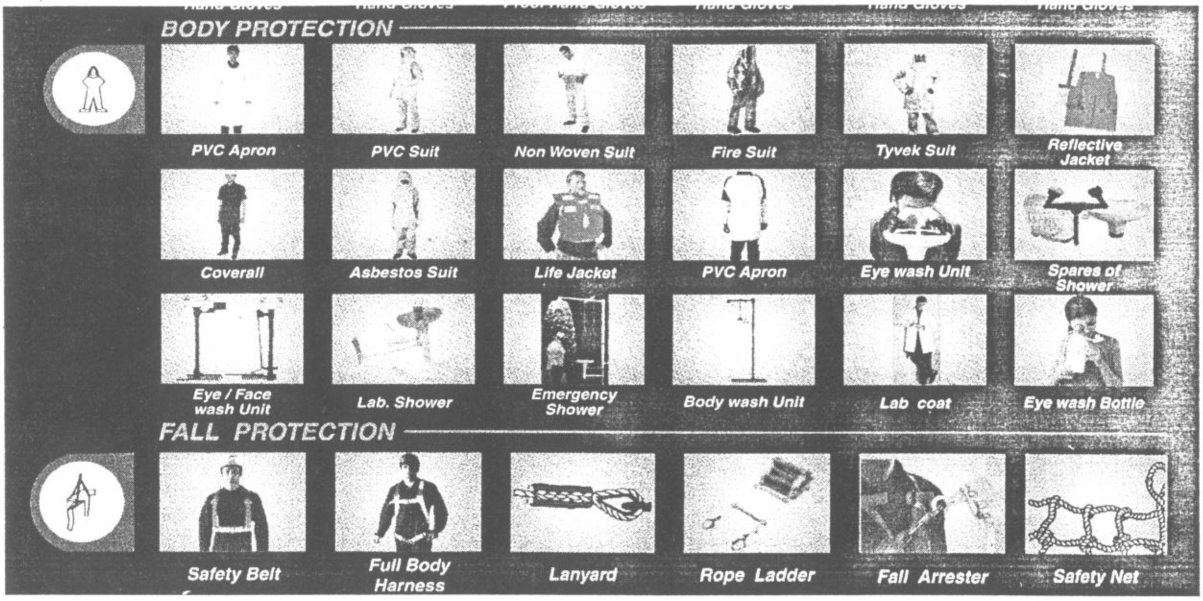
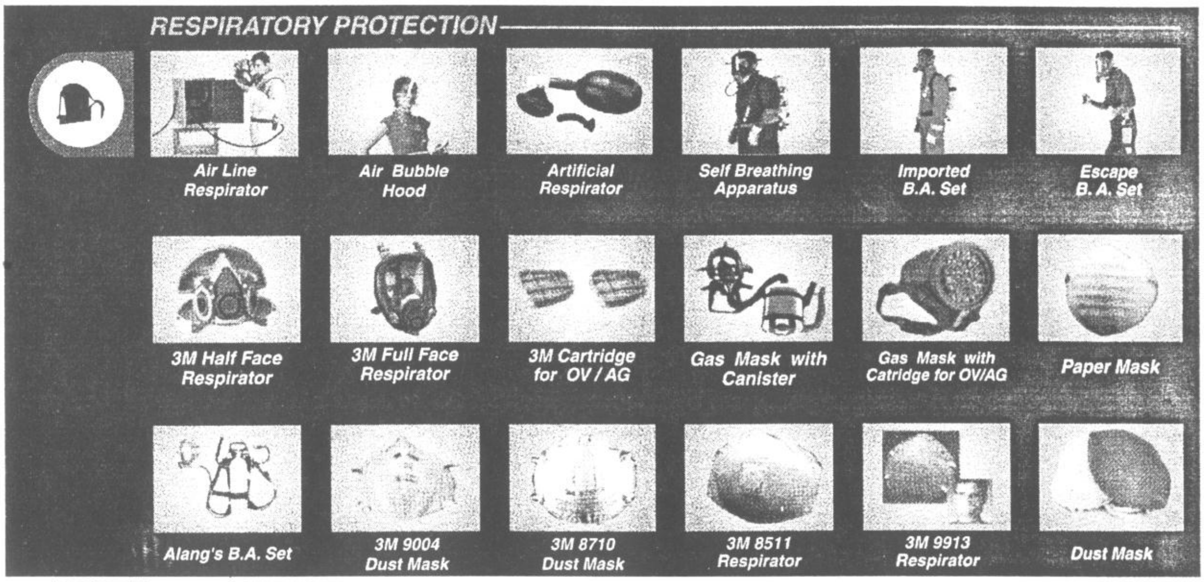


Fig. 25.1 (B) Non Respiretory PPE



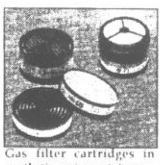
Self contained open circuit breathing apparatus with seamless steel cylinder. CAP.:6L/300 bar& 9L/200 bar.

Life Oxygen pack : Provides supplementary oxygen with inhalator for breathing victim & through a resuscitator for non breathing victim. Cap. : 6LPM CF & 0 to 25 LPM.

Short duration emergency escape breathing app. Half mask attachment & alarm whistle. 2 Ltr steel cylinder

Full face mask with wide vision. Available in Polychloroprene & silicon rubber for use with gas filters.

Half mask with gas filters.



Gas filter cartridges in synthetic resin containers.

Self contained breathing apparatus (SCBA)

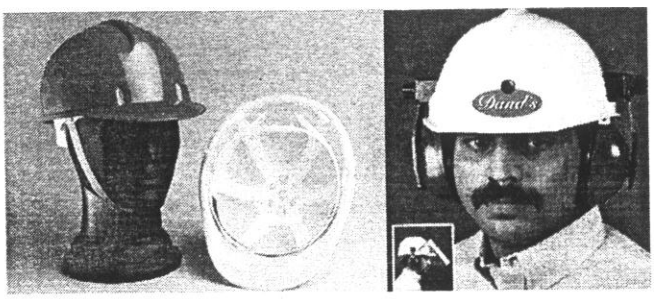
Fig. 25.2 Respiretory PPE

Utility and characteristics of head protectors an shown in Table 25.3

Table 25. 3 : Head Protectors

Type	**Protects Against**	**Characteristics**
Safety Helmet (Hard hat)	Falling objects, hitting against obstructions such as low ceilings, beams, scaffold members etc.	Generally made of aluminium alloy, PVC, fibre- glass, or vulcanized fibre. Saddle (geodetic strap suspension) inside to dissipate impact pressure over wide area of head and to provide clearance between the head and the shell of helmet. Chin strap or other device to prevent displacement. Peak and full brim to protect face, neck, ears. Ventilation holes for comfort.
Electrical Safety Helmet	Electric shock when working near live electrical lines.	Made of synthetic electrically non-conductive materials (PVC etc.)
Welder's Cap	Falling welding spatters from above.	Made of leather with cloth lining inside.
Crash Helmet	Skull injuries in road accidents.	Usually fibre / plastic material with saddle inside, without peak or rim and with chin strap. Covers forehead, temples and lower portion of head (above neck)

Soft caps and hoods are also used for protection against heat, spark and other dangerous materials and are made of appropriate materials. Some time hoods are made with rig frame which is held away from the head.



Long hair or beards may be caught in moving machine parts (e.g. belts, chain, in-running nips etc.) while seeing or leaning down or by heavy static charges. Protective caps covering the hairs are useful.

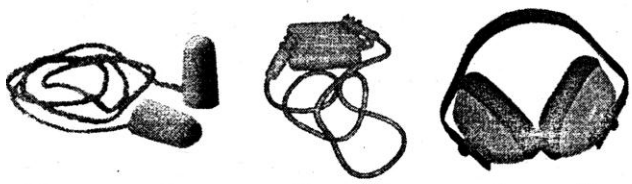
Hair net is not a full protection. The hair cap should be of flame- retardant material for protection against sparks or hot metal. It should be cool, lightweight, adjustable and with visor infront.

Types of equipment available :

Adjustable head gear and chinstrap.
Sand/shot blasting helmet.
Glass fibre safety helmet.
Safety helmet attached to ear muff.
Darvic plastic helmet.
Safety helmet made of aluminium.
Black fibre or moulded fibre glass.
Hard hats and safety caps.
V-Guard protective caps & hats.
Topguard protective caps & hats.
Thermalguard caps & hats.
Skullguard protective headwear.
Shockguard caps & hats.
T-aluminium caps & hats.
Vanguard helmets for lateral protection.
Winter liners.
Foldback faceshield frames for caps & hats.
Welding shields.
Auto change welding helmet.
Universal cap & hat adapters.
Sparkguards.
Goggle retainer (on helmet).
Chin straps.
Defender fire helmets.

5.2 Ear Protection :

See Chapter-12 for permissible noise levels and control measures in detail. Hearing loss is an occupational disease under Sch.3 of the Factories Act, IQAR



Foam ear plug with cord   Ear seal with cord   Ear muff

Noise level above 90 dBA is hazardous for an exposure more than 8 hrs/day or 48 hrs/week. It may cause deafness, fatigue, loss of efficiency, irritation and also loss of hearing. Noise level can be measured by a noise average meter or a noise dose meter. Ear plugs or Ear muffs reduce to @ 25 to 40 dBA. Ear plug is made of plastic, rubber or polyurethane foam. Ear muffs covers external ear and provides better attenuation than ear plug.

See Part 6.7 of Chapter-12 for ear protectors.

Types available :

Ear muffs, or cups (circumaural).
Plugs or inserts.

Dielectric ear muff.
Formable (disposable) aural inserts.
Full enclosure (e.g. astronaut).
Superaural or canal cap.

5.3 Face and Eye Protection :

Eye injuries can be caused by mechanical, chemical, thermal and radiation hazards such as dusts, flying particles, splashes and harmful radiation. Eye protectors are safety spectacles, mono goggles, impact goggles, welding goggles, foundry goggles, chemical goggles, gas tight goggles, face shields, welding helmets etc. Possible hazards are :

1	Large flying particles from	Chipping, fettling, riveting, sledding, chalking.
2	Dust and small flying particles from	Scaling, grinding, stone dressing, wood working.
3	Splashing of metals from	Pouring of liquid metal from ladle, crucible etc., casting of metals, galvanizing and dipping in molten metals.
4	Splashing of liquids, gases and fumes from	Handling of acids and other chemicals.
5	Reflected light, glare and radiant energy from	Foundry work, glass furnaces, gas welding and cutting, arc welding.

Utility and characteristics of eye protectors are shown in Table 25.4.

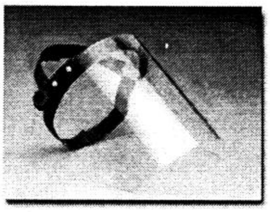
Table 25.4 : Eye Protecors

Type	Protects Against	Characteristics
Spectacle-type Goggles	Flying bodies (dust, metal chips, etc.)	Plain, shatter – proof, toughened glass or plastic lenses. With or without side shields. Metal or heat –resistant frame.
Panorama Goggles	Oil and paint splashes, dust and chip exposure	Light in weight, Non-fogging cellulose clear visor. Ventilation holes on either side. Soft pliable plastic frame wide enough to wear over prescription glasses.
Leather-mask Goggles	Smoke, dust, foreign bodies	Sweat lining along edges, ventilation holes with baffles for light and dust. Shatter-proof lenses.
Chemical Goggles	Chemicals and toxic dusts	Acid / alkali – resistant rubber frame with clear lenses and shielded ventilating ports.
Gas-tight Goggles	Irritating fumes, vapour or gases	Airtight – fitting without ventilating ports.
Welding Goggles	Gas Welding/ Cutting. Flames &	Similar to panorama goggles

	sparks	with filter glass of suitable grade and indirect ventilation ports.
Welding Shields	Arc Welding / Cutting flames and sparks	Fibre or fiberglass shield, hand-held or suspended from helmet, with window for filter glass.

Eye and face protection standards are provided for - Rigid and non rigid welding helmets. Welding hand shields. Attachments like lift fronts, chin rests, aprons, magnifiers, snoods etc.. Face-shields, Flammability, Goggles for welder, cutter, chipper (eye cups) and dust & splashes and Spectacles of metal, plastic or combination.

Face Protection



Face Shield

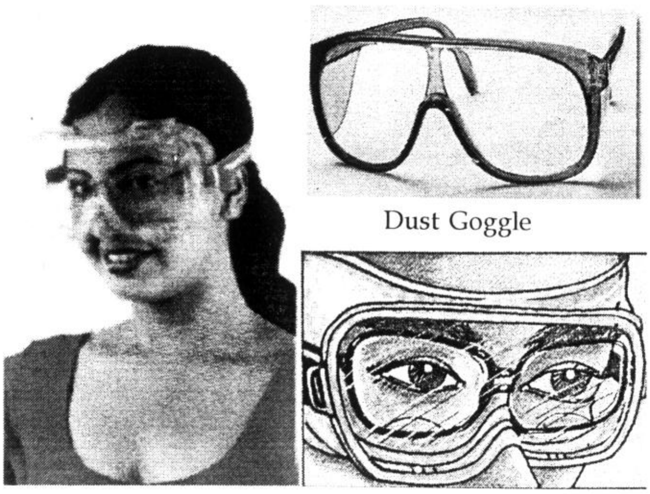
Plastic face shield with acrylic visor, and Darvic guard with fibre/PVC head band, with adjustable head gear helmet attached to face shield.

Welding screen shield.

Furnace masks.

Eye Protection

Large vision red vinyl goggles with perspex lens and sponge lining.



Dust Goggle

Chemical Splash Goggle

Panorama type.
Full view perspex goggle.
Plastic spectacle with ventilated side shields.
Welding goggle.
Fibre goggle for grinding, chipping etc.
Gas tight goggle.
Rubber frame goggle.
Leather mask goggle.
Bakelite general purpose goggle.

Metal frame spectacle.
Stoker's goggle.
Dust goggle.
Furnace goggle.

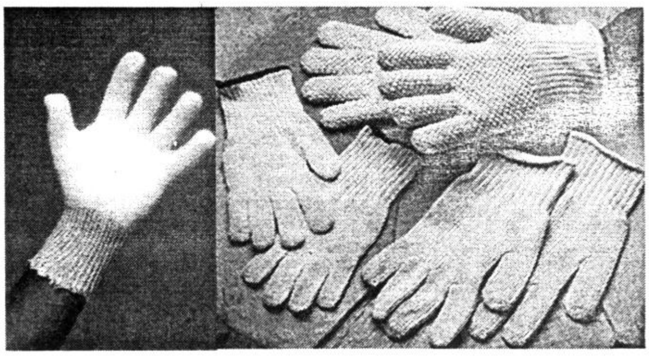
Laser eyewear should be marked with optical density values and wavelengths for which they are to be used. Laser glasses or goggles designed for specific wavelengths should not be used for different wavelengths of laser radiation.

5.4 Hand and Arm Protection :

Protection of hands and arms are required when workers have to handle materials having sharp end, sharp edges, hot and molten metals, chemicals and corrosive substances. The protective equipment may be gauntlet gloves, wrist gloves, mittens, hand pads, thumb and finger guards and sleeves. Gloves, hand leathers, arm protectors, finger stalls, mittens etc. should not be used near moving machinery or machine parts. Selection guideline is given in Table 25.5.

Table 25.5 Selection of Gloves :

	Material	Protects against
1	Asbestos	Sparks, hot materials, heat.
2	Chrome leather	Sparks, hot materials, hot liquids, flying particles, cuts, abrasions.
3	Flame proofed Duck	Sparks, hot materials, heat, flying particles, machinery.
4	Plastic	Hot liquids, moisture, acids and alkalis, demartitis.
5	Rubber	Hot liquids, moisture, acids and alkalis electric shock, dermatitis
6	Chemical resistant material	Acids and alkalis
7	Reflective fabric	Hot liquids
8	Plastic rubber coated fabric	Hot liquids, moisture, acids and alkalis
9	Metal Mesh	Cuts and abrasions
10	Cotton Canvas	Cuts and abraisons



Glove material selection should be asunder :

1. Natural rubber gloves are stretchable and highly resistant to punctures. Thiey perform well in mild caustics and ketone-based solutions and in temperatures ranging from 0°F to 300 "F. These gloves

work well for job which require handling rough materials or sharp-edged objects such as plate glass and lumber.

2. Neoprene is a premium-grade, synthetic rubber. Gloves coated with neoprene are resistant to strong acids, oils, grease, solvents and caustics. They perform well in temperatures from 0°F to 300 °F.

3. Nitrile is a super synthetic compound available in either a smooth or rough finish. They perform well in temperatures from 25°F to 300 'F. Nitrilecoated gloves offer superior abrasion, snag and puncture resistance for tasks such as handling coarse building materials and rough castings.

4. Viton gloves are especially useful for resisting chemical permeation from chlorinated and aromatic solvents as well as many other liquids and vapours.

5. Polyvinylchloride (PVC) plastic gloves resist a broad range of chemicals and abrasives. They provide ample flexibility and durability in temperatures ranging from 25°F to 150 °F. PVCcoated gloves are ideal for jobs which involve handling rough machine parts, castings or petrochemicals.

6. Butyl rubber gloves offer high permeation resistance to many gases and vapours.

7. Latex gloves are not appropriate for primary chemical resistance but offer good protection from standard grit/grime.

Utility and characteristics of hand protectors are shown in Table 25.6.

Table 25.6 : Hand Protectors

Type	Protects against	Characteristics
Leather gloves	Cuts, bruises, abrasions, lacerations during handling of metal sheets and other sharp-edged objects and sparks	Plain, cut-resistant leather with or without metal mesh at palm.
Aluminised fabric gloves	Flames, intense heat radiation, burn injuries	Heat-resistant aluminized fabric or other special material
Asbestos gloves	-do-	Padding inside for comfort and to withstand high temperatures
Acid / Alkali-proof rubber / synthetic gloves	Corrosive chemicals (organic acids or petroleum products)	Rubber, neoprene or vinyl material
Lead – lined gloves	Ionising radiation (X-rays, gamma rays, etc.)	Rubber, leather or plastic with lead lining.
Canvas gloves	Grease oil, dust and dirt which may cause slipping of hands	Fabric or coated fabric
Electirc gloves	Low voltage electric shocks (up to 4000 V) High voltage electric shocks (tested 11 KV)	Made of insulated rubber having required dielectric strength and electrical resistance. Generally red in colour
Barrier Cream	Contact dermatitis from solvents, lubricants and other oils.	

Types available :

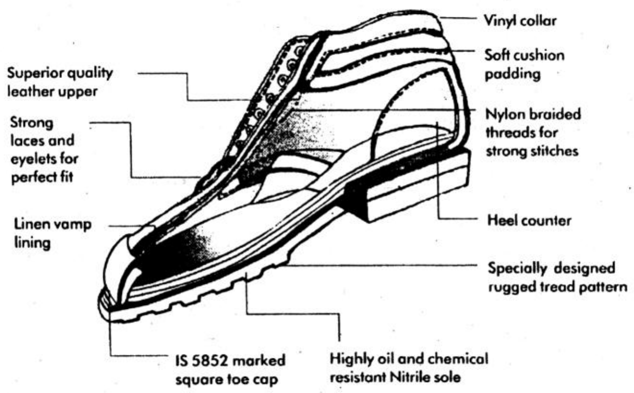
Chrome or plain leather gloves.

Mittens, Gauntlets.
Corrugated rubber gloves.
Cotton gloves.
Asbestos gloves or mittens.
Sleeves made of leather, asbestos, rubber, or PVC.
Iron hand gloves.
Chemical resistant gloves.

5.5 Foot and Leg Protection :

Some typical risks are handling of heavy materials, caustic and corrosive liquids, wet conditions, molten metals, etc. Common foot and leg protective equipment are safety shoes or boots, leggings and footguards. Leg guards (e.g. Cricketer type) are used to protect - shins against impact. Knee pads are worn by mould loftsmen and others who do continual kneeling. Selection is as follows:

Safety shoes/boots may be conductive, non conductive or spark resistant. Rubber boots are useful to work in wet conditions, steel toe boots against impact and puncture resistant soles to walk on surfaces having nails, sharp objects etc.



Conductive shoes allow draining of static charges and non-ferrous shoes reduce possibility of friction sparks and much useful in fire/explosion prone area. Conductive footwear resistance should not exceed 450 kilo ohms.

Conductive shoes are used where floors are nonconductive and grounded such as in manufacture of certain explosive compounds or while cleaning tanks that have contained solvent or volatile hydrocarbons. These shoes have conductive soles and non-ferrous metal parts.

Foundry workers should wear gaiter or congress type safety shoes which have no fasteners or lashes and rapidly removable. The tops of the shoes should be covered by full pant leg, spats or leggings to keep out molten metal.

Electricians need insulated shoes with non-metal parts. Leather shoes are useful to work in wet condition. Wooden soles to walk on hot surfaces and rubber shoes for working with acids and alkalis but not with solvents which dissolve the rubber.

Hazard-wise selection is shown in Table 25.7 and Material-wise selection in Table 25.8 anc 25.9.

Table 25.7 : Feet Protection

Hazards	Protection
Falling, rolling objects and materials	Shoes with steel toe-caps. Aluminium, steel fibre or plastic instep to protect top of feet
Sharp cutting edges, wood chips, glass shards, nails	Steel spring in –soles.
Chemicals, solvents, alkalis, caustics, bleaches, cutting oils and compounds, grease, creosol.	Non-soluble natural rubber, vinyl, plastic footwear, synthetic rubber, neoprene, cord or cork soles
Oily floors	Synthetic rubber or chrome leather soles
Hot surfaces, sparks, metal splashes	Heat-resistant soles, slip-on wooden sandals over shoes; foundry boots with elastic band or buckle for quick removal; trouser legs rolled down over boot tops
Extreme heat and direct flame	Insulated or aluminized over-shoes or boots of fire-resistant material
Fungal infection from prolonged exposure to water	Lined rubber shoes. Silicone- treated leather or rubber shoes for minor or occasional wetness
Sparks can ignite flammable gases, liquids and explosives	Shoes with non-ferrous metal parts, steel toes covered with non-sparking material.
Static electricity built up in the body can ignite volatile material	Shoes with special conductive soles of cork, leather etc.
Skids and slips; icy surfaces	Cleated, wooden, non-slip or neoprene soles. Slip-on non – skid sandals ; strap – on cleats.
Live circuits or equivalent	Electrically non-conductive standard safety shoes.
Sanitation hazards; Contamination and infection	Special plastic over shoes; paper or shower shoes. Disposable strictly not to be re-used.
Safety footwear must be carefully chosen for maximum protection and its suitability for the particular hazard. Care and proper maintenance are of vital importance. Footwear must be regularly inspected. Worn-out or defective shoes should be immediately repaired or replaced. Defective footwear should never be worn. Footwear must always be kept clean and dry.	

Table 25.8 : Material for Knee Pads, Leggings etc.

	Material	Protects against
1	Asbestos	Sparks, hot materials, heat.
2	Chrome leather	Sparks, hot materials, hot liquids, flying particles, cuts, abrasions.
3	Flame proofed Duck	Sparks, hot materials, heat, flying particles, machinery.
4	Plastic	Dermatitis, hot liquids, moisture, acids, alkalis.
5	Rubber	Dermatitis, hot liquids, moisture, acids, alkalis, electric shock
6	Fibre metals	Sparks, flying objects, flying, particles,

		cuts, abrasions, machinery.
7	Chemical resistant material	Acids and alkalis
8	Reflective fabric	Hot liquids

Table 25.9 : Material for Shoes and Boots

	Material	Protects against
1	Steel toe caps	Falling bodies
2	Non-skid shoes	Moisture.
3	Wooden soles	Hot materials, heat, hot liquids, moisture, acids and alkalis, slips and falls, cuts, abrasions.
4	Chrome leather.	Sparks, hot materials, heat, hot liquids
5	Rubber	Hot liquids, moisture, acids and alkalis, electric shock, dermatitis.
6	Conductive rubber	Explosive.

Types Available:

Leggings:

Leather legging and spats.
Asbestos hip leggings.

Boots and Shoes:

Safety leather boots.
Asbestos clogs or boots with leather soles.
Asbestos long boots.
Rubber gum boots.
Leather ammunition boots.
Leather/rubber sole shoes with or without steel toe.
in Oxford, Jodhpuri or Ankle style.
Electric shock-proof shoes tested to 11 KV.
Welder's safety boots.
Miner's boots. Hunter's shoes.

5.6 Body, Skin and Fall Protection :

Body protectors are coats, waist, aprons, overalls, jackets and complete head to toe protective suits. Aprons of different materials are used for protection against blows, splashes, radiant heat, flying particles etc. Pads are used to protect shoulders and back from bruises. Impervious clothing of rubber or synthetic fabrics are used for protection against water, moisture, dusts, vapours and liquid chemicals.

Nature of potential hazard, degree of the hazard involved and nature of activities of the wearer are important in the selection of safety clothing. Although complete coverage of the body and legs is not needed in many cases, unnecessary safety clothing may hamper the efficiency of the wearer. No compromise should be made with strict safety requirements. Selection is as follows :

	Material	Protects against
1	Asbestos	Sparks, hot materials, heat.
2	Chrome leather	Sparks, hot materials, hot liquids, flying

		particles, cuts, abrasions.
3	Plastic or Rubber	Hot liquids, moisture, acids, and alkalis, electric shock, dermatitis, machinery.
4	Canvas	Flying particles, cuts, abrasions, machinery.
5	Chemical resistant fabric	Acids and alkalis
6	Reflective fabric	Hot liquids

Types of body protection available are :

Body Protection :- Asbestos combination suit, asbestos jacket, hood, clogs, boots and gloves, mittens, aprons, spats, leggings, furnace mask; rubber apron with hood combined, low weight rubber coated fabric suit, low weight PVC coated fabric suit, heavy duty PVC suit or rubber coated fabric suit, PVC or rubber coated aprons with sleeves, sand or shot blast helmet rubber mat for electrical purpose, vulcanised fibre face mask for radiant heat, PVC splash proof coat, PVC hood with protected ventilator, PVC pressure suit, PV(boiler suit, overall, coat-pant and hood.

Special work clothing includes leather or wool clothing, asbestos or aluminised clothing and flame retardant or fireproof work cloths.

Safety Belts :- Linesman leather belt, leather safety strap or belt, man-hoisting leather belt, safety belt of harness made from leather or cotton webbing, nylon safety belt. Quick-on coverall harness. Suspension harnesses. Wrist rescue systems. Descent system. Total encapsulating suit harness. Linemen's belts. Structural steelworker's, car dropper's and derrick worker's belts, Shock-absorbing lanyards. Retractable lanyard, Retractable lifeline. Winches, Rope grabs. Horizontal lifeline system. Rail slider anchorage connector. Surehold confined space positioning equipment or system.

Skin covers the whole body and it is the first defensive barrier for body protection. Therefore skin protection cannot be avoided. Types of skin affecting hazards can be classified as under :

- Hazards to Skin
- Physical
  - Environmental
    - Heat, sun, cold, wind, radiation, moisture, drying up (desiccation)
  - Mechanical
    - Blows, pressure, abrasion, cuts, scrapes, laceration, puncture, bruises, vibration (white finger disease)
- Chemical
  - Burns, dermatitis, ulcers, cancer, warts, wrinkles etc. due to a variety of chemicals
- Plant Products
  - Irritation, lesions, itching, dermatitis due to plants, vegetables, fruits, flowers, wood, dust & resins, leaves, roots, stems, bulbs, sap, lacquers etc.
- Living Agents
  - Bacteria, viruses, fungi, parasites, insects, mites, grain itch, copra itch etc.

Preventive measures should include -

1. Frequent skin washing using proper cleansers.
2. Changing contaminated clothing and washing and drying the cloths properly.
3. Removal of irritants and chemicals (including oils) by effective washing using shower bath, eye washer fountain etc.
4. Wash immediately cuts, scrapes, punctures etc. and apply antiseptic bandage and seek medical advice.
5. Use appropriate PPE to protect skin, fingers, foot and body. Selection of proper goggles, gloves, footwear, aprons, overalls and clothing is important. Avoid loose clothing and exposed skin or body parts to moving machinery, high temperature, toxic chemicals (e.g. pesticides) etc.
6. Barrier creams to protect against dermatitis, lubricants, solvents, hydro-carbons etc.

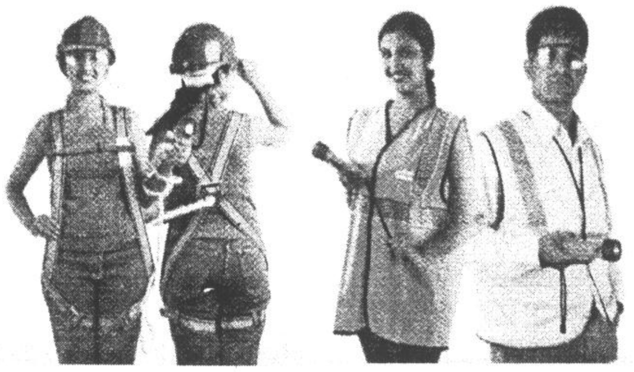
Following types of aprons are useful for skin protection:

Aprons for Skin Protection

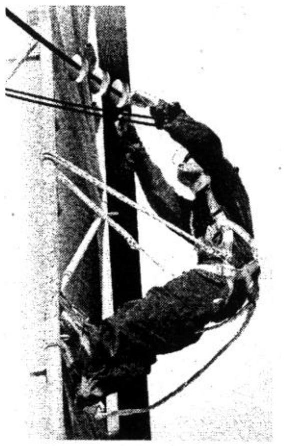
Type of Apron	Protects against
PVC, Acid / alkali proof rubber, Face shield with visor	Chemical splashes
Leather	Hot materials like molten slag, chips, hot or sharp surfaces.

Asbestos	Heat radiation
Lead	Ionising radiation (X-rays, Gamma rays)

Fall protection for the body includes safety belts, lifelines (ropes) and lanyards, harnesses (belts & straps with buckles) and fall-arrester devices or safety net.



Full body harness Reflective jacket



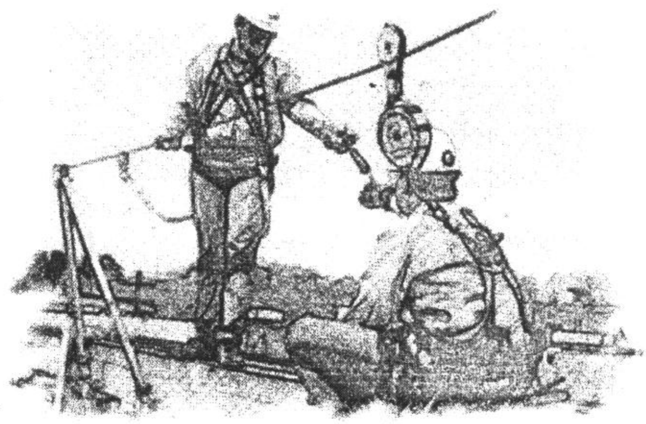
Full body harness with safety Belt and fall arrester device

It is important to note that such safety belts and associated equipment are used when fall hazards cannot be eliminated by strong support like railings, floors, platforms etc.

OSHA Standard has prohibited the use of a body belt-only for fall arrest and a fall arrest system is suggested, since 1-1-1998.

Body belts are used where less than I m free fall is anticipated and a body harness (belts or straps on chest, shoulders and thighs) is used for a limited fall upto 2 m. A harness can spread the shock load over the shoulders, thighs and seat (hips). The body belt or lifeline D-ring should be arranged at the back of the worker. The wearer of the safety belt should not tie off below waist level (to prevent turning down head). A window cleaner's belt length is limited to 8 ft (2.5 m). The chest belt is worn loosely to allow smooth breathing.

The lifeline may be vertical from a fixed anchorage or horizontal between two fixed anchorage



Horizontal Lifeline

independent of the work surfaces Lanyard is a flexible .line up to 6 ft (1.8m) to secure the wearer's harness (D-ring) to a lifeline or fixed anchorage. Lanyards may be made of nylon or other fibrous or metallic material and non-stretchable to limit free fall distance. -Shock-absorber lanyards are available to absorb up to 80% of the stopping force of a normal lanyard. Metal lanyard must not be used where electrical hazard is possible. Snap hooks (locking type •preferable) and D-rings should be maintained in good condition. Knots or lengthening of lanyards must be avoided.

Body belts (work belts) are used to reduce the probability of falls. Chest harnesses are used where there is limited fall hazard (not vertical free fall) such as for removal of a person from a tank or bin. Body harnesses, covering chest, shoulders and thighs, are used to arrest the most severe free falls.

Retrieval method is necessary to shorten the hanging distance after a fall upto 6 ft (maximum limit of free falls, for more fall height, other supporting fixed structure must be provided by fencing, railing, platform, fixed-ladder with platform and handrails etc.). Retractable lifeline, which will be shorten automatically (e.g. spring action) after its full length, can limit falls to inches and avoid prolonged suspension causing high discomfort to a hanging person.

Fall arrester net, if used, should be tied firmly as near as possible under the working place to minimize the fall distance.

Belts, harnesses, lifelines, lanyards, buckles, joints, D-ring etc. should be checked for weak points, washed regularly and kept dried at room temperature.

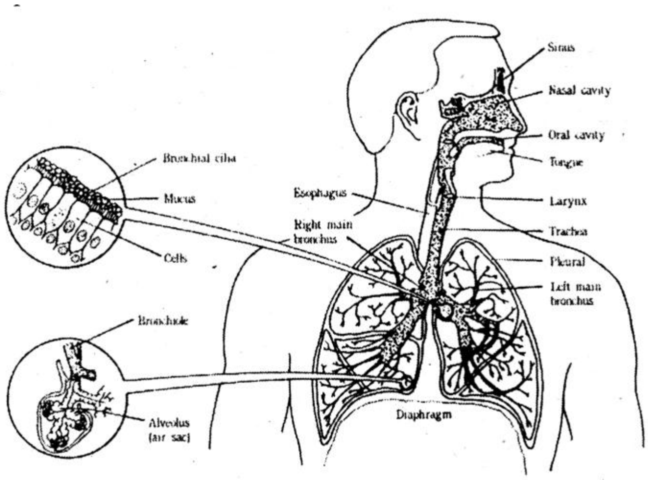
See Chapter-16 for other details.

6 RESPIRATORY EQUIPMENT

See fig. 25.2 for respiratory equipment.

The Respiratory System

Respiration is the act of inhaling fresh air into the lungs and exhaling stale air from them. When we breathe in and out, our chest cavity housing the lungs, expands and contracts. The entire rib cage, curving round the chest, is flexible and expands readily by special muscles.



The nose, mouth, upper throat, larynx, trachea, bronchi (all air passages) and the lungs where oxygen is passed into the blood and carbon dioxide expelled, are the respiratory organs that form the respiratory system. The diaphragm and chest muscles perform the movements of inspiration and expiration. The system is an intricate one with built-in safeguards against normal,, everyday hazards. The nostrils (hairs) filter dust particles from inhaled air; the specially structured nasal passage monitors the air temperature; the mucous secreted by the membrane in the nasal passage continuously drips into the throat, heating and moistening the inspirited air and trapping bacteria and dust. There are many other such barriers but they are obviously no match against sustained onslaughts of unusual and ruinous hazards posed by contaminated or higher concentration of toxic chemicals, dusts, mists, gases and sprays.

Broadly speaking, oxygen-deficient air and harmful toxic contaminants in the atmosphere are the major respiratory hazards.

Atmospheric contaminants include harmless substances to toxic dust, fumes, smokes, mists, vapour and gases. Processes which present hazards of exposure to harmful substances should be closed or ventilated to eliminate or minimise the hazard. If enclosure, ventilation or -other engineering controls are not possible, respiratory equipment should be provided to the workers exposed to such hazard. Even though engineering controls are applied satisfactorily, supply of appropriate protective equipment should be readily available for use, as plant breakdown, maintenance or repairs may have to be carried out in contaminated environments.

Respiratory protective equipment should be considered a last resort, or additional stand-by protection and never a substitute for effective engineering control.

Workers should be aware of other routes of entry also (e.g. skin contact and oral) and looking to such nature or possibility of chemicals, they should adopt other protections also.

Selection of respiratory protection depends On

1. Identification and classification of hazards.
2. Evaluation of the hazard i.e. measurement of concentration and to decide which worker(s), which process, place or environment need respiratory protection, and
3. Selection and application (use) of the appropriate type of the equipment.

Protection Factor (ratio of measured or suspected concentration / TLV) is important in selection of a respiratory PPE. It should be higher if the toxicity of the gas is higher. If varies from 4 to 10. It is like a factor of safety.

6.1 Classification of Respiratory Hazards:

Type of hazards to which a worker is exposed is the basis of selection of the right type of respiratory protective equipment.

Respiratory Hazards:

Before initiating a respiratory protection program, it is important to first understand the types of respiratory hazards inherent to your industry.

Of the three normally recognised ways toxic materials can enter the body - (1) through the gastrointestinal tract. (2) skin and (3) lungs - the respiratory system presents the quickest and most direct avenue of entry. This is because of the respiratory system's direct relationship with the circulatory system and the constant need to oxygenate tissue cells to sustain life.

There are three basic classifications of respiratory hazards: oxygen-deficient air; particulate contaminants; and .gas and vapour contaminants.

6.1.1 Oxygen Deficiency :

Normal ambient air contains an oxygen concentration of 20.8 percent by volume. When the oxygen level dips below 19.5 percent, the air is considered oxygen-deficient. Oxygen concentration below 16 percent is considered unsafe for human exposure because of harmful effects on bodily function, mental processes and co-ordination.

It is important to note that life-supporting oxygen can be further displaced by other gases, such as carbon dioxide or nitrogen. When this occurs, the result is often an atmosphere that can be dangerous or fatal when inhaled. Oxygen deficiency can also be caused by rust, corrosion, fermentation or other forms of oxidation which consume oxygen. The impact or oxygen-deficiency can be gradual or sudden.

Atmospheres in confined spaces such as vats, tanks, hold of the ships, etc. may contain air with oxygen content much lower than normal (21% by volume). This may be due to dilution or displacement of the air by other gases or vapours or because of loss of oxygen due to decay of organic matter, chemical reaction and natural oxidation over a long period of time. A person breathing air with oxygen content of 15% or less may exhibit symptoms ranging from increased rate of breathing, acceleration of pulse rate to unconsciousness and death,. Such oxygen deficiency condition can easily be detected as the flame of a safety lamp will be extinguished in such atmosphere. Oxygen deficient atmosphere is immediately dangerous to life. The respiratory protective equipment in such conditions should either supply normal air or oxygen to the wear. Self contained or combination breathing apparatus is suitable.

6.1.2 Gaseous Contaminants :

Gas and vapour contaminants can be classified according to their chemical characteristics. True gaseous contaminants are similar to air in that they possess the same ability to diffuse freely within an area or container. Nitrogen, chlorine, carbon monoxide, carbon dioxide and sulphur dioxide are examples.

Vapours are the gaseous state of substances that are liquids or solids at room temperature. They are formed when the solid or liquid evaporates. Gasoline, solvents and paint thinners are examples of liquids that evaporate easily, producing vapours.

In terms of chemical characteristics, gaseous contaminants may be classified as follows :

Inert Gases - These include such true gases as nitrogen, helium, argon, neon, etc. Although they do not metabolise in the body, these gases represent a hazard because they can produce an oxygen deficiency by displacement of air.

Acidic Gases - Often highly toxic (corrosive), acidic gases exist as acids or produce acids by reaction with water. Sulphur dioxide, hydrogen sulphide and hydrogen chloride are examples.

Alkaline Gases - These gases exist as alkalis or produce alkalis by reaction with water. Ammonia and phosphine are such examples.

In terms of chemical characteristics, vaporous contaminants may be classified as follows :

Organic Compounds - Contaminants in this category can exist as true gases or vapours produced from organic liquids. Gasoline, solvents and paint thinners are examples.

Organometallic Compounds - These are generally comprised of metals attached to organic groups. Tetra-ethyl-lead and organic phosphates are examples.

These may be toxic or inert gases or vapours. The toxic gases may produce harmful effect even if they are present in relatively low concentrations. The inert gases produce undesirable effects primarily by displacement of oxygen. Vapours are from volatile, evaporating liquids. Gaseous contaminants can also be classified as

1. **Gaseous Contaminants Immediately Dangerous to life:** These contaminants are gases present in concentrations that would endanger life of a worker breathing them even for a short period of time. In other words, a gas is immediately dangerous to life if it is present in certain concentration. Where it is not possible to determine the extent 6f concentration or the kind of gas, all gases should be considered as immediately dangerous to life and health. IDLH values of many gases and dusts are available. Positive pressure self-contained or combination breathing apparatus is suitable.

2. **Gaseous Contaminants not immediately Dangerous to life :** These contaminants are gases present in concentration that could be breathed by a worker for a short time without endangering his life but which may cause possible injury after a prolonged single exposure or repeated short exposures. But even after the concentrations of the contaminant is known, no exact formula can be applied to determine if the contaminant is immediately dangerous to life or not. Air - line respirator, hose mask with or - without blower and chemical cartridge respirator are suitable.

6.1.3 Particulate Matter or Contaminants :

Particulate contaminants can be classified according to their physical and chemical characteristics and their physiological effect on the body. The particle diameter in microns (1 micron = l/ 25400 inch) is of utmost importance. Particles below 10 microns in diameter have a greater chance to enter the respiratory system and particles below 5 microns in diameter are more apt to reach the deep lung or alveolar spaces.

In the healthy lungs, particles from 5 to 10 microns in diameter are generally removed by the respiratory system by a constant cleansing action that takes place in the upper respiratory tract. However, with excessive "dust" exposures or diseased respiratory system, the efficiency of the cleansing action can be significantly-reduced.

The various types of airborne particulate contaminants can be classified as follows :

Fumes - An aerosol created when solid material is vaporised at high temperatures and then cooled. As it cools, it condenses into extremely small particles generally less than I micron in diameter. Fumes can result from operations such as welding, cutting, smelting or casting molten metals.

Dusts - An aerosol consisting of mechanically produced solid particles derived from the breaking up of larger particles. Dusts generally have a larger particle size when compared to fumes. Operations such as sanding, grinding, crushing, drilling, machining or sand blasting are the worst dust producers. Dust particles are often found in the harmful size range of 0.5 to 10 microns.

Mists - An aerosol formed by liquids, which are atomised and/or condensed. Mists can be created by such operations as spraying, plating or boiling, and by mixing or cleaning jobs. Particles are usually found in the size range of 5 to 100 microns.

Majority of particulate contaminants are not immediately dangerous to life. They may be solid, liquid or a combination of solid and liquid and may be classified into three broad groups- dust, mist and fumes. Dust and fumes are solid flying particles, fumes being extremely small. Mists are tiny liquid droplets given off by spraying or .very fast mixing or agitating.

Dust, mist or fume respirator, air-line respirator and abrasive blasting respirator are suitable.

Types of contaminants can also be classified as under:

1. **Toxic particulate contaminants :**
These when inhaled may pass from the lungs into the blood stream and are then carried to the various parts of the body. The effect may be chemical irritation, systemic poisoning or allergic reactions. Common contaminants in this group are antimony, arsenic, cadmium, chromic acid and chromate, lead and manganese.
2. **Fibrosis-producing dusts:**
These dusts do not pass into the blood stream but remain in the lungs and may cause pulmonary impairment. The common example under this group are asbestos, coal, iron, bauxite and free silica.

3. **Nuisance Dusts :**

These may dissolve and pass directly into the blood stream or may remain in the lungs neither producing local nor systemic effects. Examples are saw dust, chalK clay, starch, cement dust etc.

6.1.4 Combination of Gaseous and Particulate Contaminants:

Here gaseous and particulate contaminants occur together as in case of paint spraying where solvent vapour (gas) and paint mists are mixed. They may be entirely of different substances like carbon monoxide and oxides of nitrogen produced by blasting or volatile liquids.

For contaminants immediately dangerous to life, positive pressure self-contained or combination breathing apparatus or gas masks with special filter and for not immediately dangerous to life, air line respirator, hose masks with or without blower and chemical cartridge respirator with special filter are suitable.

6.2 Classification of Respirators :

Respiratory protective equipment are already classified in foregoing Part-4 of this chapter. They are of two types : Air-supplying or Air-purifying. Air supplying respirators include air-line respirator, self breathing (air or oxygen) apparatus, suction hose mask, pressure hose mask etc. Air-purifying respirators include canister, cartridge or filter respirators which need replacement of these parts. They are briefly described below:

6.2.1 Air Supplying Respirators :

(1) Airline Respirators:

Airline respirator consists of a face-piece (half or full mask or a loose fitting helmet or hood) to which air is supplied through a small diameter hose. It may be a continuous flow type or a demand type.

Air Line Respirator

In a constant or continuous flow type, air is supplied continuously to the face piece helmet or hood. air or the excess air entering the face-piece escapes to the atmosphere. Air supplied should be at least 110 litres of air per minute to enter the face-piece and at least 170 litres per minute to enter the helmet or hood.

Abrasive blasting (e.g. shot or sand blasting) respirator is a continuous flow type airline respirator with the addition of mechanical protection for head and neck from abrasive particles.- It may cover shoulder and chest also.

In a pressure demand type respirator, air is supplied to a face-piece when the wearer inhales and the rate is governed by his volume rate of breathing. Air from an air compressor cylinder is supplied to the face-piece through a demand valve which is actuated by the slight negative pressure created when the wearer inhales. On exhalation the demand valve closes and exhaled air escapes to the surrounding atmosphere through exhalation valve. Helmets or hoods are not used with demand type respirator.

Airline respirators provide protection so long as the air supply is maintained but the wearer's travel is restricted by the length of the air supply hose. They are not used in IDLH atmosphere. Air temperature and pressure should be comfortable and the air should be supplied through an air-cleaner. Care should be taken to ensure that the air supply is respirable and is not contaminated and is free from objectionable odours, oil or water mist and rust particles from the supply line. The air line connection should be tight (nondetachable) and should be checked before use. One worker died due to detachment of air supply line when he was working in oxygen deficient atmosphere (95% Nitrogen) to fill a pyrophoric catalyst in a .reactor.

(2) Suction Hose Mask :

It consists of a full face piece connected to a large diameter flexible hose. The worker draws in air by his own breathing effort, the hose is attached to the wearer's body by a suitable safety harness with safety line and the air inlet end of the hose is provided with a filter to arrest particulate matter. Air can be drawn in by respiratory effort of the wearer upto 30 ft length of the hose.

(3) Pressure Hose Mask (Air supplied hoods):

This hose mask or hood is similar to suction hose mask except that the air is forced through a large diameter hose by a hand or motor-operated blower or compressor. The blower is to be operated continuously while the mask is in use. Respirable air of comfortable pressure and temperature should be supplied at least 6 ft^3/min.

(4) Air-Supplied Suits:

Air line respirators are used where normally nose and face are exposed to hazards and not the other body parts. But where all body parts including nose, need protection, for example, to do any repair or emergency work in extremely corrosive atmosphere affecting skin and mucous membranes or acutely toxic and immediately dangerous to life, a full body suit of impervious clothing with respirable air supply, is a must.

The air line is connected to the suit 'itself and also to helmet and distributing air evenly throughout on the body, because without such ventilation and cooling effect, it is very difficult and fatiguing to wear such suit for a longer time. Particularly, in our country where majority of the days are hot, workers are reluctant to wear such full suit. They should be properly explained its need and utility. They should be rotated in case of more inconvenience.

6.2.2 Self-Contained Breathing Apparatus :

They are of two types.

(1) Self-Contained Compressed Air or Oxygen Breathing Apparatus:

This is a device by means of which the wearer obtains respirable air or oxygen from compressed air or oxygen cylinder which is an integral part of the apparatus.

In a demand type Self-Contained breathing apparatus, air or oxygen is admitted to the face piece through a two stage pressure reducing mechanism, only when the wearer inhales and the quantity of air or oxygen admitted is governed by his breathing. The wearer's exhaled breath escapes to the surrounding atmosphere.

In compressed oxygen cylinder recirculating type breathing apparatus, high pressure oxygetl from the cylinder passes through a pressure reducing and regulating valve into a breathing bag. The wearer inhales this oxygen through a one-way breathing valve and his exhaled breath passes into a canister containing chemicals to absorb exhaled carbon dioxide and moisture and then through a cooler into the same breathing bag. Oxygen enters the breathing bag from the supply cylinder only when the volume of gas in the bag has decreased sufficiently to allow the supply valve to open.

From respiratory point of view, self-contained breathing apparatus has no limitation as to the concentration of the gas or deficiency of oxygen in the surrounding atmosphere but other factors may limit the time that the wearer can remain in a contaminated atmosphere. Many gases are very irritating to the skin and many can be absorbed in dangerous amounts through the unbroken skin.

(2) Oxygen-Regenerating Recirculating type Self-Contained Breathing Apparatus:

In this type of apparatus moisture content from the wearer's exhaled breath reacts with granular chemical in a canister to liberate oxygen. Also the exhaled carbon-dioxide is absorbed by the chemicals in the canister. The oxygen enters the breathing bag from which the wearer inhales through a corrugated breathing tube connecting the bag to the face-piece.

6.2.3 Air Purifying Respirators :

Air purifying respirators purify the air of gases, vapour and particulate, but do not supply clean or fresh air. Therefore they must never be used in oxygen deficient atmosphere. Purification of breathing air is done by mechanical filtration, adsorption, chemical reaction or catalysis.

The life of such respirators depends on concentration of the contaminant, scrubbing capacity of the medium (cartridge) and breathing demand of the wearer. The respirator has a face piece and a connected canister (box) or cartridge to purify the air passing through it.

The canister or cartridge should not be used -

1. After its date of expiry or after 100 hours after its first use.
2. When air coming to nose, gives irritation, smell or indication of saturation or non-effect of the scrubbing medium.
3. When oxygen is less than 18% in air.
4. When the gas or vapour has no smell or odour.
5. When the gas or vapour is highly toxic.
6. When the gas or vapour is highly irritating to eyes without necessary eye protection, and
7. Above the limit of concentration marked on it.

Main types of air-purifying respirators are explained below:

(1) Canister Gas Mask :

This consists of a canister, containing appropriate chemical, a full face-piece and body harness to hold the canister. Air is drawn through the canister by the wearer and during its passage through the chemical in the canister the contaminant present in the incoming air is absorbed and reacted with the neutraliser. The canisters are designed for specific gases and it is very important that the appropriate type is used.

The canister gas mask can only be used in atmosphere not deficient in oxygen and not containing more than 20% by volume of most toxic gases. Also, the life of the canister will depend upon the type of canister, the concentration of gas and the activity of the wearer.

(2) Chemical Cartridge Respirator :

This consists of a half-mask attached to one or two cartridges.. Like canisters, the cartridges are filled with appropriate chemicals to absorb gases or vapours drawn through them. This respirator is a non-emergency gas respirator and it should not be used in an atmosphere deficient in oxygen. Like canister gas mask, chemical cartridge respirator provides respiratory protection for a period that depends on vapour concentration and the wearer's activity. It is recommended for low concentration gases and vapours, 0.1% or 1000 ppm of organic vapour, acid gases upto 500 ppm, ammonia upto 700 ppm and mercury vapour.

(3) Self-rescue type Respirators :

This is designed to provide the greatest possible respiratory protection consistent with the practicability of carrying the device at all times so that it is always available for use during escape. It consists a filter element, a mouth piece, a nose clip and means of carrying conveniently on the body. The filter elements are similar to chemical cartridge. The extent of protection afforded is between that provided by canister gas mask and that provided by a chemical cartridge respirator.

Colour code of canister/cartridge as given in IS 8318 and 8523 is given in Table 25.10.

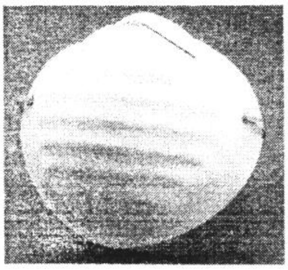
Table 25.10 : Colour Code of Canisters

No.	Gas in polluted air	Colour of canister
1	Acid gas	White
2	Organic vapour	Black
3	Ammonia gas	Green
4	Carbon monoxide gas	Blue
5	Acid gas & Organic vapour	Yellow
6	Acid gas, Ammonia & Organic vapour	Brown
7	Acid gas, Ammonia, Carbon monoxide & Organic vapour	Red
8	Gases & vapours other than above	Olive
9	Radioactive materials (except tritium & noble gases)	Purple
10	Dust, Fume & mist (except radioactive materials)	Orange
11	Any vapour or gas with organic substance	Purple strips
12	Any vapour or gas with Dust, Fume & Mist	Orange strips
13	Chlorine	White with yellow strips
14	HCN gas or vapour	White with green strips

In addition to the above colour identification, full instructions on the canister/cartridge must be read to understand its correct use, suitability, duration, limitation etc.

(4) Mechanical Filter Respirators :

These remove particulate matter from the inspired air which passes through a filter. These filters may be of the single use or re-usable type. If these respirators are used in heavy concentrations of particulate matter, the filling will be clogged with dust particles too quickly and they may have to be replaced every now and then,. Micro filters are special filters designed to arrest ultra microscopic size of dust particles and these are used where extremely fine dusts are encountered.



Such filters screen out dust, fog, fume, mist, spray, smoke etc. through a filter or pad but they cannot be used against 0 deficiency, gases, solvents and vapours.

Powered air-purifying respirators use a blower to pass the contaminated air through an element that removes the contaminant and supplies purified air to the face-piece.

(5) Combination of Chemical and Mechanical Filter Respirators:

They remove toxic gases and vapours and particulate matter from inspired air. Common example of their use is in spray painting work. They are also known as 'Gas Masks'.

Types of respirators are shown in Table 25.11.

Table 25.11 : Types of Respirators

Type	Protects Against	Characteristics
Dust respirator	Nuisance dusts and pneumoconoiosis producing dusts, powders, mists having TLV (Threshold Limit Value) not less than 0.1 mg/m^3 of air	Single or double filters of lint, cotton wool, etc. which can be replaced when plugged with particulate matter. Resin impregnated wool fitler for dust of 10 micron or less
Light Chemical Cartridge Respirator	Light concentration of fumes say 0.1% by volume – of acid fumes 7 paint spray.	Mouth cum nose piece. Activated charcoal used for absorbing gases & fumes.
Heavy Chemical Cartridge Respirator	Light concentrations of acid fumes and specified gases. Usually for concentration not exceeding 0.1% by volume.	Mouth cum nose piece having usually a mixture of calcium hydroxide with sodium or potassium hydroxide used as reacting agent.
Canister Gas Masks	Specified fumes / vapours/ gases not exceeding a concentration of 2% by volume for a maximum period specified by supplier (usually 30 min.)	Face piece or mouth piece connected by a flexible tube to a canister containing neutralizing chemical for specified gases.
Self-contained breathing apparatus (SCBA)	Oxygen deficient environment and toxic gas environment of high concentration.	Compressed air or oxygen cylinder supplies breathing air / oxygen; full face mask connected to the cylinder.

Types of respirators available :

Aluminium, alu-foil, anti-dust, protective hood, air-line reinforced plastic hood, fresh air hose apparatus, pressure hose apparatus, face mask with canister, face mask with screw filter canister, small gas filter, oxygen breather, compressed air breathing apparatus, protective suits for fire fighting and rescue operation, automatic resuscitator, plastic foil respirator, cloth mask, dust guard, full. vision face mask, lung protector, fibre glass hood respirator, pressure fresh air hose apparatus etc.

6.2.4 Selection, Instruction and Training in the use of Respirators :

Respiratory protection programme should include - Policy and administration, identification, measurement, evaluation and control of respiratory hazards. Selection and use of proper respiratory PPE, Training, inspection, maintenance and repair of equipment. Medical surveillance and review of the programme.

The following factors should be considered for selection of the respirators:

1. Nature of the hazard.
2. Severity of the hazard.
3. Type of contaminant.
4. Concentration of the contaminant.
5. Protection factor which should be
   $\geq$ Hazard Ratio = Contaminant concentration / TLV
   Assigned protection factors to respirators are as under:

Air purifying respirators - Half mask 10
- Full facepiece 50

Powered air purifying respirators
- Loose fitting facepiece 25
- Half mask 50
- Full facepiece 1000

Supplied Air respirators (Airline) -
- Continuous flow - Loose fitting facepiece 25 ;-Halfmask50
  - Full facepiece 1000
- Pressure demand with full facepiece 1000 SCBA 1000

6. Period for which respiratory protection must be provided.
7. Location of the contaminated areas with respect to a source of respirable air.
8. Expected activity of the wearer, and
9. Operating characteristic and limitations of the available respirator.

Instructions for care should include the following aspects :
1. Why and how it is to be used.
2. Protecting the equipment from dust, heat, moisture, extreme cold and damaging chemicals. Storing in a dry cool place.
3. Checking that it is in good operating condition. Valves should be maintained in efficient working condition.
4. Fitting of respirator on the wearer and
5. Proper use and maintenance of the respirator.
6. Cleaning and keeping it in a sealed plastic bag with name tag of the user.

Training for respiratory equipment should include following points :

1. Reasons of need of respiratory protection and limitation or inability of other controls or methods.
2. Identification and understanding of the hazard for which the equipment is to be used and selection procedure;
3. Limitation, capability, function and operation of the respirator.
4. Proper fitting, wearing, adjusting face piece & valves and removing of the respirator.
5. Maintenance and storage procedure.
6. Practice to wear first in a safe atmosphere to become familiar with its characteristics.
7. Practice to wear in a test atmosphere under close supervision of the trainer, and to do similar activities and to detect respirator leakage or malfunction.
8. How to ascertain and handle emergency situation.
9. Statutory provisions regarding use of respirators.
10. When and how to replace filters, cartridges, canisters and cylinders.
11. Instructions for special use if any.

The trainer should be qualified safety officer, industrial hygienist, safety professional or manufacturer's representative

6.2.5 OSHA Standard for Respiratory Protection:

Program Requirements:

The OSHA Respiratory Protection Standard (29 CFR 1910.1-34) lists seven key elements that every respiratory protection program should contain. These include :

1. A written plan detailing how the program will be administered.
2. A complete assessment and knowledge of respiratory hazards that will be encountered in the workplace.
3. Procedures and equipment to control respiratory hazards, including the use of engineering controls and work practices designed to limit or reduce employee exposures to such hazards.
4. Guidelines for the proper selection of appropriate respiratory protective equipment.
5. An employee training program covering hazard recognition, the dangers associated with respiratory hazards, proper care and use of respiratory protective equipment.
6. Inspection, maintenance and repair of respiratory protective equipment, and
7. Medical surveillance of employees.

Administration:

The responsibility for administration of these procedures should be assigned to one individual who may, and probably will, have assistance. The necessity for a central authority is to ensure consistent coordination and direction. The actual respiratory protection program will vary widely depending upon many factors and may require input from specialists such as safety personnel, industrial hygienists, health physicists and physicians. But program responsibility should reside with a single individual if the program is to achieve optimum results.

The first step in a respiratory protection program is to establish written standard operating procedures governing the selection and use of respirators.

Finally, there should also be regular inspection and evaluation of the program itself to ensure its continued effectiveness.

For types of respiratory hazards see Part 6.1

Hazard Assessment:

Proper assessment of the hazard is the first important step to protection. This requires a thorough knowledge of .processes, equipment, raw materials, end-products and by-products that can create an exposure hazard.

To determine an atmosphere's oxygen content or concentration levels of particulate and/or gaseous contaminants, air samples must be taken with proper sampling instruments during all conditions of operation. The sampling device, the type and frequency of sampling (spot testing or continuous monitoring) will be dictated by the exposure and operating conditions. Breathing zone samples are recommended and sampling frequency should be sufficient to assess the average exposure under the variable operating and exposure conditions.

If contaminant concentrations exceed exposure limits recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), OSHA or NIOSH, hazard control procedures must be implemented promptly.

Exposure monitoring plays a critical role in the respirator selection process. The results from such tests will help you determine whether respiratory protection is needed and, if it is, the type of respirator required. Generally respirator selection is based on three factors:

1. The results of your atmospheric monitoring or sampling programme,
2. The accepted ACGIH, OSHA or NIOSH exposure limits for the substance(s) present and

3. The maximum concentration (of a substance) for which a respirator can be used.

Exposure limits include ACGIH Threshold Limit Values (TLVs), OSHA Permissible Exposure Limits (PELs), NIOSH Recommended Exposure Levels (RELs) and AIHA Workplace Environmental Exposure Levels (WEELs). These values are guides for exposure concentrations that healthy individuals can normally tolerate for eight hours a day, five days a week without harmful effects. Unless otherwise noted, exposure limits are eight-hour, time-weighted-average(TWA) concentrations.

In general, gas and vapour exposure limits are expressed in ppm by volume (parts of contaminant per million parts of air), while particulate matters (concentrations) are expressed as mg/ 3 (milligrams of concentrations per cubic meter of air). For substances that can exist in more than one form (particulate or gaseous), concentrations are expressed in both values.

It is important to note that exposure limits and other exposure standards are constantly changing as more data is gathered about specific chemicals and substances. As such, you must be certain that you are using the most recent data when determining allowable exposure levels for employees.

Hazard Control:

Hazard control should start at the process, equipment and plant design levels where contaminants can be effectively controlled at the outset. With operating processes,, the problem becomes more difficult. In all cases, however, consideration should be given to the use of effective engineering controls to eliminate and/or reduce exposures to respiratory hazards. This includes consideration of process encapsulation or isolation, use of less toxic materials in the process and suitable exhaust ventilation, filters and scrubbers to control the effluents.

Because it is sometimes not practical to maintain engineering controls that eliminate all airborne concentrations of contaminants, proper respiratory protective devices should be used whenever such protection is required.

Respirator Selection:

Respiratory protective devices vary in design, application and protective capability. Thus, the user must assess the inhalation hazard and understand the specific use limitations of available equipment to assure proper selection.

The respirators fall under two classifications : air-purifying and air-supplied. Air-purifying respirators are used against particulate, gases and vapours. These include negative-pressure respirators that use chemical cartridges and/or filters; gas masks; and positive pressure units such as powered air-purifying respirators (PAPRs), Air-supplied devices rely on a primary air source to deliver a steady flow of respirable air to the user's facepiece. These include SCBA and airline devices.

For training, maintenance and care of PPE, See Part 7.

Medical Surveillance:

Workers should never be assigned to any operations requiring respiratory protection until a physician has determined that they are capable physically and psychologically to perform the work using the respiratory protective equipment.

Although instituting a sound respiratory protection program will take effort and financial investment, the objective of such a program is sound - ensuring that every worker is protected against potentially fatal diseases.

6.2.6 Cleaning Procedures for Respirators:

1. Remove filters, cartridges, or canisters. Disassemble facepieces by removing speaking diaphragms, demand or pressure-demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.
2. Wash components in warm (43°C/110°F maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.
3. Rinse components thoroughly in clean, warm, preferably running water. Drain the components.
4. When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in-

   Hypochlorite solution (50 ppm of chlorine made by adding approximately one milliliter of laundry bleach to one liter of water at 43°C/110°F), or

   Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters of tincture of iodine (6-8 grams ammonium and/ or potassium iodine/lOOcc of 45% alcohol) to one liter of water at 43°C/110°F
5. The importance of thorough rinsing is most important. Detergents or disinfectants that dry on facepieces may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.
6. Components should be hand-dried with a clean, lint-free cloth, or air-dried.
7. Reassemble facepiece, replacing filters, cartridges, and canisters where necessary.
8. Test the respirator to ensure that all components work properly.

7 TRAINING, MAINTENANCE, PRECAUTION AND CARE OF PPE

Training :

For proper use of any respiratory protection device, it is essential that the user be properly instructed in its selection, use and maintenance. Both supervisors and workers must be so instructed by competent persons:

Minimum training must include the following:

1. Methods of recognising respiratory hazards.
2. Instruction in the hazards and an honest appraisal of what could happen if the proper respiratory protection device is not used.
3. Explanation of why more positive control is not immediately feasible. This must include recognition that every reasonable effort is being made to reduce or eliminate the need for respiratory protection.
4. A discussion of why various types of respiratory protection devices are suitable for particular purposes.
5. A discussion of capabilities of the device and limitations.
6. Instruction and training in actual use of respiratory protection equipment and close and frequent supervision to assure that it continues to be properly used.
7. Classroom and field training to recognise and cope with emergency situations.

Training should provide personnel with an opportunity to handle the device, have it fitted properly, test its face-to-face piece seal, wear it in normal air for long familiarity period and, finally, to wear it in a test atmosphere.

Training is very important for supervisors who have to supervise the use of any type of personal protective equipment as well as for the users. Generally no one should wear personal protective equipment until he has been thoroughly trained to use it correctly. He should know

1. The hazards for which protection is required, control measures provided or not possible.
2. Reasons of selection of particular type of PPE.
3. The limitations of the equipment.
4. How to wear, use and remove each equipment. Removal is particularly important where the equipment may be contaminated with a highly toxic material.
5. Demonstration how to fit, adjust and use the PPE and practice by the worker for that.
6. How to clean, repair and maintain in good condition the PPE.
7. How to inspect for damaged equipment to ensure adequate protection.
8. How to deal with emergencies, and
9. Location of the equipment before and after use.

Training should be given by a qualified safety professional or manufacturer's representative and may include lectures, demonstrations, drills and on the job guidance. Training should include new and most suitable PPE available in the market.

Maintenance :

It is a cooperative activity between the employee who takes care of his equipment and the safety professional who teaches him how to use it and provides proper instructions. After inspections, cleaning and necessary repair, personal protective equipment shall be stored to protect against dust, sunlight, heat, extreme cold, excessive moistures or damaging chemicals to retain its original effectiveness. When in doubt about the maintenance of any type of personal protective equipment, it is a good practice to contact the manufacturer. All PPE should be cleaned and examined after each use. Respirators should be cleaned daily. Face-piece should be washed in warm water with soap or a detergent. Filter and chemical cartridge should be replaced when needed.

General Precautions to use PPE :

Following precautions are useful for training and practice

1. Hazards at workplace must be thoroughly studied, gas, oxygen, contamination, noise etc. should be measured and their level should be minimised by engineering controls first and then only the need of necessary personal protective equipment (PPE) should be ascertained.

2. PPE should be kept ready and in sufficient number. Gloves, shoes, goggles, aprons, earplugs etc. should be given individually and kept clean by the worker in his locker.

3. PPE should be of approved (IS) quality and tested before use. Manufacturer's instructions, limitations, time limit if any, procedure or method of use, symptoms of malfunctioning, emergency action if it does not work and instructions for maintenance and care should be well understood before using any PPE.

4. Written instructions should be prepared and displayed or given to the workers for the safe use of the equipment. After medical examination of the worker, need and type of the equipment shall be reconsidered. Change if any, should be incorporated.

5. Laziness in using PPE is not good. A cloth in place of effective respirator is insufficient. Avoiding PPE because the use is for a few seconds or minutes, is unsafe.

6. Loose PPE should be kept away from the moving machine parts.

7. While entering in a tank or working at height, safety belt must be worn, in addition to good sitting and supporting arrangement (safe platform or fencing). Gas and oxygen level should be measured and kept safe as far as possible. PPE shall be selected based on its level.

8. Cotton clothing in hot days, woollen clothing in cold days and tight fitting clothing while working near machinery are 'basic requirement. Synthetic cloths are unsuitable to health. PPE on cotton clothing gives more comfort.

9. A man working on electricity should wear nonconductive helmet. Conductive shoes or clothing are required to discharge static electricity induced in a human body.

10. Canister gas mask and dust mask are useful for low concentration (100 to 200 ppm) and for the gas and duration mentioned on the mask only. Filter is to be changed or cleaned soon after choking. Canister gas mask is not useful if oxygen is insufficient (less than 18%) in air. Different types of gas masks are recommended for different level of concentration.

    Canister mask is not safe while working in a tank. When gas is less than 5% of LEL, canister mask may be worn just to clean the tank. If this level is from 5 to 20% of LEL, airline respirator may be used. If concentration is more than this it should be diluted.

    Six months old canister mask should not be used. Every six months its chemical is to be freshly filled. It should not be used after 100 hours after breaking its seal. If face piece is used by another person, it may be reused only after sterilisation. User of a gas mask should get his heart and lungs checked by a doctor.

    Canister mask of a gas which has no smell (e.g. CO, PH_3), should be used new every time. Gas mask should be kept away from moisture and heat and should be regularly checked.

11. Chemical cartridge and dust respirators can be used where flammable gas, fume or dust concentration is so low that canister mask is not necessary. When the gas is poisonous or in high concentration, eye burning, or without smell or where oxygen is insufficient, chemical cartridge or dust respirators cannot be used. The cartridges should be kept dry. If they are moist or giving smell, they should be changed. Valves for inhale and exhale should be checked and kept efficient.

12. Where oxygen is less, gas, dust or smoke are more, toxic gases like $C1_2$, CO, H_2S, PH_3 phosgene exist, proper canister gas mask is not available or where one has to work in a tank for a long time, an airline respirator is useful, because fresh air is available through blower or air compressor and polluted air is being driven away near the nose. But because of the limited length (80 mt maximum), where one has to move at a longer distance or upstairs and downstairs at different floors, only SCBA is useful.

    Connections (joints, clamps, clips etc.) of air line should always be checked before use, otherwise accidental detachment of air supply will cause harm to .the wearer. Air drawing point should not be kept in polluted air. Air filter (cleaner), air control valve, safety valve and alarm are all necessary. Air flow should not be less than 6 ft3/min and its temperature should be comfortable. If hydrocarbon gas content is more than 20% of LEL, it is unsafe to enter into a tank with air hose mask. Air inlet valve should not be completely closed (it should remain partially open).

Cooling effect and circulating air type suits are also available which are useful in working near high temperature.

13. Earplugs should be washed with soap and' water, dried and put into its box after every use. Earplugs used by others should be sterilised before use. Earplugs should be supplied individually to the workers. Ear muffs should also be cleaned before and after use.

14. Fire rescue (proximity) suit should be worn by two persons at a time so that one may act as a standby. Air cylinder and lifeline should also be kept ready.

15. Safety belt should be kept clean, dry and in sound condition. Its connections and wear and tear should be checked before every use. Its free end should be tied with a fixed (immovable) structure while working at height or given in another person's hands while entering in a tank.

    Strength members of a safety belt should be of very sound material other than leather. Buckles should withstand 1315 kg tensile test and be quickly openable.

    Lifeline should not be of pieces tied together. Nylon rope of '/2 inch diameter is safe. Wire rope should be made oily before and after using it in acidic atmosphere. Metallic life line shall not be used near electric work.

16. Nothing should be kept in helmets. It should be checked for crack and proper fitting.

17. Contact lenses are to be protected against gas, vapour, fumes, excessive heat, molten metal and chemical splashes. Therefore safety goggles over the lens or numbered glass are always necessary. Safety .goggles are also necessary with the faceshield. When goggles or faceshield are splashed with chemicals, they should be washed by a water shower before taking out from the face. Plastic lenses are more useful than glasses. Side shields are useful.

18. Mechanical filter respirators are useful for dust and smoke. Filters are to be changed or cleaned when choked. Mechanical filter respirators are not suitable for solvent vapour, toxic gas or oxygen deficiency. In fire fighting work, only SBAis useful and not the gas mask.

19. A respirator should be carefully selected while working in IDLH (immediately dangerous to life and health) environment. An operator is necessary with blower hose mask. One can run away till the air is available from the hose even when the blower is closed. While working with SBA, one should come out after hearing the low pressure alarm.

20. No other gas mask than SBA or air line is useful where oxygen is less than 18%. Level of oxygen should be measured with oxygen meter.

21. When gas concentration is more than its safe limit or within explosive range (between LEL and UEL) or oxygen is less than 18% in a tank, (or confined space), it should be ventilated by air (not by oxygen), the levels should be again measured and when they are safe, permit to enter should be signed.

22. Air supplying hoods are useful in hot or dusty atmosphere to work for a longer time.

23. Where atmospheric pressure is more than 2 bar, oxygen SBA should not be used because of the possibility of oxygen poisoning. Quick start canister used in closed circuit oxygen self generating (recirculating) SBA, may prove dangerous in atmosphere of gas having less than 315 °C auto ignition temperature. Venting device to release excess oxygen is required in that case. Used canister should be disposed safely. SBA should be used by a healthy and trained worker only.

24. In empty air cylinder, oxygen should not be filled. It may cause fire due to contact with oil or grease.

25. Safety toe shoes should withstand 300 ft pound impact load. Resistance of conductive shoe should not exceed 450 kilo ohms.

    Electrician's boots should not have any metal parts, and steel toe if any, should be insulated.

    Sole with flexible metal sheet inside, give protection against nails and sharp edges.

26. Where full hand gloves are not required,, stalls for fingers, mittens or pads for palms, and other PPE for thumb, wrist, palm and elbow are also available.

    Leather gloves are Useful to work with glass or metal sheet or sharp edges but not useful to work above 65 °C temperature.

    Natural rubber is not suitable to work with oil, grease or organic solvent.

    Hand gloves with any metal part are not suitable for electric work. High voltage tested rubber gloves are suitable for such work.

27. After the use is over, PPE should not be left anywhere. They should be returned to the proper person or put in a cupboard meant for it.

28. Arrangement for keeping, cleaning, testing and disposal of PPE should be provided and every such person should be properly trained in addition to the user.

Respirator Care :

Proper inspection, maintenance and repair of respiratory protective equipment is mandatory to ensure success of any respiratory protection program. The goal is to maintain the equipment in a condition that provides the same effectiveness it has when first manufactured. Inspection

All equipment must be inspected periodically before and after each use. A record shall be kept of all inspections by date with the results tabulated. Follow precisely the recommendations of the manufacturer. Maintenance

All respiratory protective equipment shall be cleaned and decontaminated after each use. Repair

Replacement of other than disposable parts must be done only by personnel with adequate training to ensure the equipment is functioning properly after the work is accomplished. Only parts supplied by the manufacturer for the product being repaired shall be used.

8 DETECTION EQUIPMENT

8.1 Classification of Equipment :

Many times with or without the personal protective equipment, various types of detection equipment are to be used as under :

Detecting Equipment (Environmental Surveillance)

- Combination Instruments
  - Passport personal alarm (multigas detector) with sampling probes, Gasport gas tester (detection of CH_4, CO, H_2S & O_2), Portable alarms (pocket instruments to detect combustible gas and O_2), Portable indicator & alarm, Remote alarms
- Combustible Gas Indicators
  - Explosimeter, Combustible gas indicators, Portable combustible gas alarm, Calibration check kits
- Toxic Gas and Oxygen Indicators
  - Organic vapour monitor, Detector tube pump, Gas tester pump, Detector tubes, Oxygen indicators, Mini series gas indicators, HazMat response kit, CO/CO_2 response kit
- Personal Sampling Pumps
  - Pump for personal & area sampling, Micro air sampler, Quick-flow area sampler, Ventilation smoke tube kit, Pump calibration check devices

Use of such detection equipment is necessary to ascertain the working environment for selection of a right type of PPE.

8.2 Detection Methods(Environmental Surveillance) :

Battery-powered, direct-reading detection instruments are classified by two groups — single-gas instruments or multiple-gas instruments — typically monitoring one or a combination of the following atmospheric conditions :

1. Oxygen deficiency or enrichment;
2. The presence of combustible gas; and
3. The presence of certain toxic gases.

Depending on the capabilities of the instrument, monitoring can be conducted simultaneously for oxygen and combustible gas or for oxygen, combustible gas and toxic gases. These devices are commonly referred to as 2-in-l, 3-in-l, 4-in-l or 5-in-l alarms.

No matter which type of instrument is used to check environmental gas concentrations, regular monitoring should be performed because a contaminant's level of combustibility or toxicity might increase even if it initially appears to be low or nonexistent. In addition, oxygen deficiency cAn occur unexpectedly.

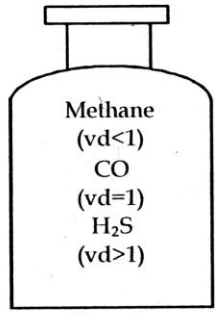
8.2.1 Atmospheric Composition:

To determine the composition of an atmosphere, reliable instruments should be used to draw air samples. If possible, do not open the entry portal to the confined space before this step has been completed. Sudden changes in atmospheric composition within the confined space could cause violent reactions or dilute the contaminants in the confined space, giving a false low initial gas concentration.

When testing permit spaces for acceptable entry conditions, always test in the following order:

1. Oxygen content,
2. Flammable gases and vapours, and
3. Potential toxic air contaminants.

Comprehensive testing should be conducted in, various locations within the work area. Some gases are heavier than air and tend to settle at the bottom of a confined space. Others are lighter and are usually in higher concentrations near the top of the confined space. Still others have the same molecular weight as air, so they can be found in varying concentrations throughout the space. This is why test samples should be drawn at the top, middle and bottom of the space to pinpoint varying concentrations of gases or vapours as shown below.



Gas position according to vapour density.

The results of the atmospheric testing will have a direct impact on the Selection of protective equipment necessary for the tasks in the area. It may also dictate the duration of worker exposure to the environment of the space or whether an entry will be made at all. Substance-specific detectors should be used whenever actual contaminants have been identified.

Combustible Gases:

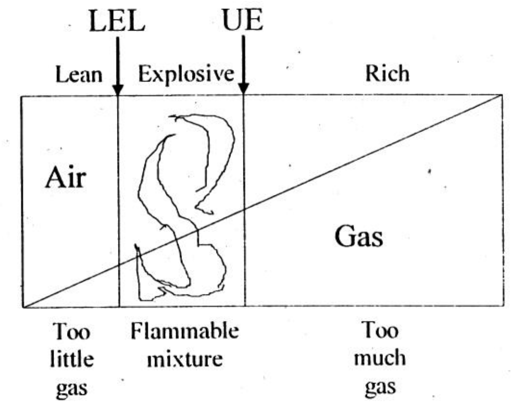
In order for combustion to occur, there must be three elements:

1. Fuel.
2. Oxygen to support combustion and
3. Heat or a source of ignition.

This is known as the fire triangle, but if you remove any one of the legs, combustion will not occur.

The percentage of combustible gas in the air is important. For example, a manhole filled with fresh air is gradually filled by a leak of combustible gas such as methane or natural gas, mixing with the fresh air.

As the ratio of gas to air changes, the sample passes through three ranges: lean, explosive and rich.



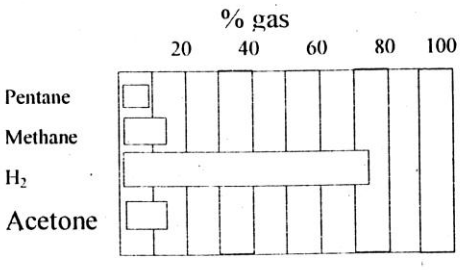
In the lean range there isn't enough gas in the air to burn. On the other hand, the rich range has too much gas and not enough air. However, the explosive range has just the right combination of gas and air to form an explosive mixture. Care must be taken, however, when a mixture is too rich, because dilution with fresh air could bring the mixture into the flammable or explosive range. An analogy is the automobile that won't start on a cold morning (a lean atmosphere because the liquid gasoline has not vaporised sufficiently), but can be flooded with too much gasoline (a rich atmosphere with too much vaporisation). Eventually, when the right mixture of gas and air finally exists (explosive), the car starts.

8.2.2 Working of Combustible Gas Monitors:

To understand how portable combustible gas detection instruments work, it is first important to understand what is meant by Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL). When certain proportions of combustible vapours are mixed with air and a source of ignition is present, an explosion can occur. The range of concentrations over which this reaction can occur is called the explosive range. This range includes all concentrations in which a flash will occur or a flame will travel if the mixture is ignited. The Lowest percentage at which this can happen is the LEL; the highest percentage is the UEL.

Most combustible instruments display gas concentrations as a percentage of the LEL. Some models have gas readouts as a percentage by volume and others display both percent of LEL and percent combustible gas by volume. What's the difference? For example, the LEL of methane (the major component in natural gas) is 5 percent by volume, and the UEL is 15 percent by volume. If we slowly fill the room with methane, when the concentration reaches 2.5 percent by volume, it is 50 percent of the LEL; at 5 percent by volume it is 100 percent of the LEL. Between 5 and 15 percent by volume, a spark could set off an explosion.

Different gases need different percent by volume concentrations to reach 100 percent of the LEL. Pentane, for example has an LEL of 1.5 percent. Instruments that measures in percent of the LEL are easy to use because regardless of the gas, you are most concerned with ho\\ close the concentration is to the LEL.

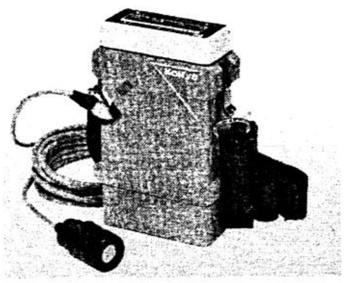


Explosive range

8.2.3 Working of different Gas Monitors :

They are explained below -

(1) Single Gas Monitors for Oxygen Deficiency


Hand held oxygen indicator with wlarm

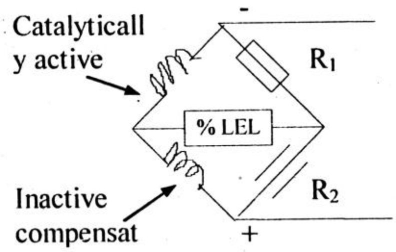
Oxygen indicators measures atmospheric concentrations of oxygen. Concentrations are generally measured over a range of 0 to 25 percent oxygen in air, with readings being displayed on either digital readout or an analog meter.

Oxygen indicators are calibrated with uncontaminated fresh air containing a minimum of 20.8 percent oxygen. With some models, an alarm is activated when oxygen levels drop below 19.5 percent.

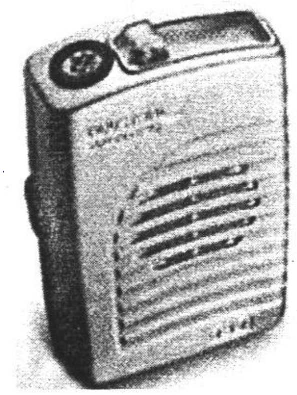
(2) Single Gas Monitors for Combustible Gases

Single-gas instruments for monitoring combustible gases and vapours are generally calibrated on pentane and are designed for general purpose monitoring of hydrocarbon vapours. Such instruments operate by the catalytic action of a heated platinum filament in contact with combustible gases. The filament is heated to operating temperature by an electric current. When the gas sample contacts the heated filament, combustion on its surface raises the temperature in proportion to the quantity of combustibles in a sample.

A Wheatstone bridge circuit, incorporating the filament as one arm, measures the change in electrical resistance due to the temperature increases. This change indicates the percentage of combustible gas present in the sample.



Wheatstone Bridge



(3) Single Gas Monitors for Toxic Gases

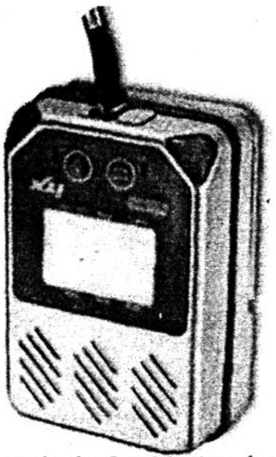
Compact, battery-powered devices can be used to measures levels of such gases as carbon monoxide (CO) or hydrogen sulphide (H_2S), depending on the model selected. Toxic gas monitors use electrochemical cells. If the gas of interest enter the cell, the reaction produces a current output proportional to the amount of gas in the sample. With these instruments, audible and visible alarms sound if the gas concentration exceeds a present level. These devises are well suited for use in confined spaces containing motors or engines, which can generate large quantities of CO, as well as in sewers, waste treatment plants and "sour crude" processing stations which tend to have hazardous volumes of H_2S.

(4) Multiple Gas Monitors for Oxygen and Combustible Gas

In applications where it is necessary to determine oxygen and combustible gas levels simultaneously, 2in-I diffusion-type devices can be used. Sensors measure 0 to 100 percent of LEL and oxygen from 0 to 25 percent Remote sampling requires either a pump module or an aspirator bulb adapter.

(5) Multiple Gas Monitors for Oxygen, Combustible and Toxic Gases

Toxic 'gases and vapours, which can be inhaled or absorbed through the skin, are frequently found in confined spaces. Sometimes, these atmospheric hazards can also displace oxygen and may incapacitate the body's ability to maintain respiration. Some toxic gases and vapours can also cause long-term physical damage to the body in cases of repeated exposure.


Multiple Gas Monitor for six gases and LEL/CH_4 over range protection

A number of instruments are available to assist in detecting toxic gases. Whereas the pocket size monitors operate by diffusion or an aspirator bulb, larger (but still handheld) 2-in-l and 3-in-l instruments have been developed with built-in pumps to draw samples from the immediate area or from outside the confined space work area when used with sampling lines. For 2-in1 devices, side-by-side analog displays show percentage for both oxygen and the LEL. With 3-in-l, 4-in-l. and 5-in-l devices, the user selects either a sensor readout on a digital display or automatic sequential scanning of sensors contained in the instruments. Regardless of the number of sensors selected or the reading being displayed, all sensors should be designed to monitor continuously.

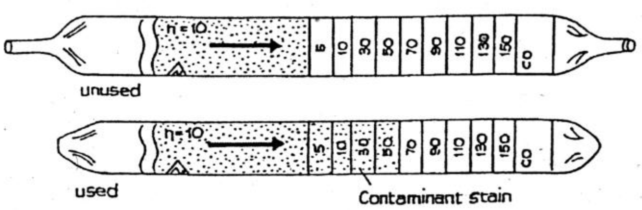
Diffusion-type instruments are available for simultaneously measuring the LEL of combustible gases, oxygen levels and toxic levels (in parts per million) of FL,S, CO and other toxic gases. Alarms also alert the user to low and high oxygen levels. Remote sampling pump adopters are available to convert these diffusion type instruments into pump-style instruments.

(6) Photoionization Devises for Toxic Gases and Vapours

A photoionization detector, featuring microprocessor technology, uses ultraviolet light to ionise molecules of chemical substances in a gaseous or vaporous state. A real-time digital readout allows the user to make an immediate determinations of gas and vapours are measured over a O.I to 200 ppm scale. Some instruments automatically compensate for signal loss due to humidity, which is inherent in all PID detectors.

(7) Detector Tube Sampling Systems

Detector tube-type devices are recommended for conducting quick evaluations of potential hazards *that cannot otherwise be measured*. With detector tubes, a known volume of air is drawn through the tube using a manually operated sampling pump. If gas or vapour is present in the air, chemically treated granules in the tube are stained a different colour. By measuring the length of the colour stain within the tube, users can determine concentration levels.



Most tubes available today are made of glass, have break-off tips, and are filled with treated chemical granules. They generally have a shelf life of 12 to 24 months.

One type of pump frequently used with a detector tube is a compact, bellows-type device. Accurate and repeatable sample flows can be assured by a shaft that guides the bellows during compression. Some models feature an end-of-stroke indicator that lets the user know when a full air sample has been drawn. Models with an integral stroke counter eliminate the tedious recording of multiple pump strokes.

(8) Personal and Area Sampling

Two kinds of sampling- personal and area- are used to determine the concentration of airborne contaminants. Personal sampling pumps are designed to measure individual worker's exposure, so they typically are lightweight, belt-mounted, battery powered devices. Area sampling pumps collect fibres in ambient air, so they usually are stationery. AC powered devices draw air in high volume.

No matter whether personal or area sampling is done, the process of sampling is essentially the same. It entails drawing a predetermined volume of air through a filter designed to trap contaminants. The filter is contained in a plastic cassette, which is attached by plastic tubing to a personal or area sampling pump calibrated to draw a specific, known volume of air into the filter. After air samples are drawn, the filters are sent to a laboratory where they are examined to determine the level of exposure.

Personal sampling determines the concentrations found in the "breathing zone" or the area near the worker's face, which is usually measured at or near the collar or lapel.

Calibration

To ensure the accuracy of all monitoring and detection equipment, calibration should be performed regularly. If the instrument reading differs significantly from the values of the known standard, the instrument should not be used until it has been adjusted or, if necessary, repaired.

See Part 1.6.5 of Chapter-24 also.

9 PPE TESTING PROCEDURES AND STANDARDS

Fit Testing

Respirators should fit properly to provide protection. To obtain adequate respiratory protection, there must be a proper match between respirator and wearer. Respirators not properly fitting cause illusion of protection. To accommodate the variability of face size characteristics among individuals, a number of manufacturers offer face pieces in several sizes and models.

Purpose:

The primary purpose of tit testing is to identify the (1) specific make (2) model, style and size of respirator best suited for each employee.

In addition, fit testing also provides an opportunity to check any problem with respirator wear, methods of donning and wearing the respirator.

Requirement:

1. Fit testing is required for all negative or positive pressure tight-fitting facepiece respirators.
2. The OSHA respiratory protection standard requires that tit testing be performed before an employee first starts wearing a respirator in the work environment, whenever a different respirator facepiece is used, and at least annually thereafter.

Method:

Prior to the actual fit test, the employee must be shown how to put on a respirator

Position it on the face, set strap tension, and determine an acceptable fit. Next, the employee must be allowed to choose a respirator from a sufficient number of models and sizes so that the employee can find an acceptable and correctly fitting respirator.

Once an acceptable respirator has been found — which takes into account the position of the mask on the face, nose, and cheeks; room for eye protection; and room to talk — a user seal check must be conducted.

Types of Fit Testing.

Fit testing may either be qualitative (QLFT) or quantitative (QNFT)

Prior to the commencement of the fit test, the employee must be given a description of the fit test and a description of the exercises that he or she will be per forming during fit testing.

The respirator to be tested must be worn for at least five minutes before the start of the fit test.

The employee must be fit tested with the same make, model, style, and size of respirator that will be used in the workplace.

Qualitative fit testing (QLFT).

Qualitative fit testing involves the introduction of a gas, vapor, or aerosol test agent into an area around the head of the respirator user.

A determination is then made as to whether or not the wearer can detect die presence of the test agent through means such as odor, taste, or nasal irritation. If the presence of the test agent is detected inside the mask, the respirator fit is considered to be inadequate.

There are four qualitative fit test protocols approved in OSHA's standard.

1. The iso-amyl acetate (IAA) test determines whether a respirator is protecting a user by questioning whether the user can smell the distinctive odor of IAA.

2. The. irritant smoke (e.g., stannic chloride) test involves a substance that elicits an involuntary irritation response in those exposed to it.

3. Before conducting a qualitative test, the worker must undergo a sensitivity test to determine if he or she can taste, smell or react to the substance.

4. When performing the iso-amyl acetate test, the protocol requires that separate rooms be used for the odor screening and fit tests, and that the rooms be sufficiently ventilated to ensure that there is no detectable odor of IAA prior to a test being conducted.

Quantitative fit testing (QNFT).

In a quantitative fit test, the adequacy of respirator fit is assessed by numerically measuring the amount of leakage into the respirator.

This testing can be done by either generating a test aerosol as a test atmosphere, using ambient aerosol as the test agent, or using controlled negative pressure (CNP) to measure the volumetric leak rate. Appropriate instrumentation is required to quantify respirator fit.

Fit Test Exercises :

The following test exercises must be performed for all fit testing methods.

Normal breathing in a normal standing position, without talking.

Deep breathing in a normal standing position, breathing slowly and deeply, taking precaution not to hyperventilate.

Turning the head slowly from side to side, while standing in place, with the employee holding his/her head momentarily at each extreme so that the employee can inhale at each side;

Moving the head up and down slowly, while standing in place, inhaling in the up position when looking toward the ceiling;

Bending at the waist as if to touch toes (jogging .in place can be done when the fit test enclosure doesn't permit bending at the waist); and normal breathing (as described above).

Retesting:

If the employee finds the fit of the respirator unacceptable, he or she must be given a reasonable opportunity to select a different respirator and to be retested. In addition, retesting is required whenever an employee reports, or the employer, supervisor, or program administrator observe changes in an employee's physical condition that could affect respirator fit. Such conditions include, but are not limited to, facial scarring, dental changes (e.g., wearing new dentures), cosmetic surgery, or an obvious change in body weight.

Facepiece Positive and/or Negative Pressure Checks :

1. Positive Pressure Check

Close off the exhalation valve and exhale gently into the facepiece. *

The fade fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal.

For most respirators, this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve, and then carefully replacing it after the test.

2. Negative Pressure Check

Close off the inlet opening of the canister or cartridge(s) by covering it with the palm of the hand(s).

Inhale gently so that the facepiece collapses slightly and hold your breath for ten seconds.

The design of the inlet opening of some cartridges cannot be effectively covered with the palm of the hand, which requires' that the test be performed by covering the inlet opening of the cartridge with a thin latex or nitrile glove.

If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is considered satisfactory.

For Standards on PPE see Part 3.

E X E R C I S E

1. Explain, state. Discuss or Mention :

1. Need and limitation of PPE.
2. Requisite characteristics of PPE
3. Types of hazards and hazard-wise PPE necessary.
4. Types and characteristics of head protectors
5. Types and characteristics of Eye protectors
6. Types and characteristics of Hand protectors
7. Types and characteristics of Feet protectors
8. Types of hazards to skin and appropriate PPE for them.
9. Criteria for selection of respirators OR their merits and demerits.
10. Types of respiratory hazards.
11. Types of Gaseous contaminants
12. Types of particulate matters.
13. Classification of Respirators and their advantages and is limitations.
14. When canister or cartridge type respirator should not be used?
15. Colour code of canisters as per IS.
16. Selection, instructions and training in the use of respiratory equipment.
17. OSHA standard for respiratory protection.
18. Training, maintenance and care of PPE.
19. General precautions for using different types of PPE.
20. Types of gas detecting equipment.

2. Write short Notes on:

1. Statutory provisions regarding PPE to be used in a factory.
2. Classification of PPE
3. Types of self contained breathing apparatus.
4. Hair protection OR Face and Eye protection.
5. Types of material for different types of shoes.
6. Preventive measures for hazards to skin.
7. Body belts.
8. Fall arrester net.
9. Respiratory system of a human body.
10. Types of Air supplying respirators.
11. Types of photo-ionization devices for toxic gases.
12. Air supplied suits.
13. Chemical cartridge respirator OR self-rescue type respirator.
14. Working of combustible gas monitors
15. Working of photo-ionization devices for toxic gases.

3. Comment on following explaining whether it is true or false ?

1. PPE is the last resort as safety measure.
2. Non-skid shoes protect against moisture.
3. Chrome leather is not suitable for hot liquids.
4. Conductive rubber protects against explosion.
5. Plastic gloves cannot prevent dermatitis.
6. Aluminium protects against ionising radiation.
7. Oxygen deficiency is not a major respiratory hazard.
8. Gas masks are useful to remove toxic gases as well as particulate matter from the inspired air.
9. Percentage of LEL is a marking criterion in combustible gas monitors.
10. Combustible gas air mixture can be ignited above UEL also.
11. For unknown contaminant canister gas mask cannot be used.
12. Carbon monoxide is a chemical asphyxiant.

4. Explain the difference between :

1. Respiratory and Non-respiratory PPE
2. Head Protection and Fall protection
3. PPE for hand and PPE for arm.
4. Air purifying and Supplied air type respirators.
5. Air line respirator and SBA.
6. PPE for eminent danger to life and that for no eminent danger to life.
7. Conductive shoes and Non-conductive shoes.
8. Steel toe boot and Non-skid boot.
9. Use of Ear-plug and Ear-muff.
10. Wire screen lenses and Polarising lenses.
11. Leaded clothing and Disposable clothing.
12. Fumes, Dusts and Mists.
13. Acidic gases and Alkaline gases.
14. Suction hose mask and Pressure hose mask.
15. Chemical filter and Mechanical filter respirator.
16. Personal sampling and Area sampling.
17. Single gas monitors and Multiple gas monitors.
18. Toxic gas monitor and Gas detector tube.

Reference and Recommended Reading

1. Industrial Hazard and Safety Handbook, king and Magid, Butterworth.
2. Indian Standards mentioned in this chapter.
3. Course Material of the Central labour Institute, Sion, Bombay.
4. Industrial Safety Handbook, W. Handley, McGraw-HillBC.
5. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
6. Sale literature of personal protective equipment manufacturing companies.
7. Personal Protection at the Workplace, LPA of India Ltd., Bombay-1.
8. Catalogues of PPE Manufacturers.
9. Quick Selection Guide to Chemical Protective Clothing by Krister Forsberg
10. PPE Made Easy by Jeffrey O. Stull
11. Practical Guide to Respirator Usage in Industry by Cyan S. Rajhans and Bhawani P. Pathak

CHAPTER – 26

First Aid

THEME

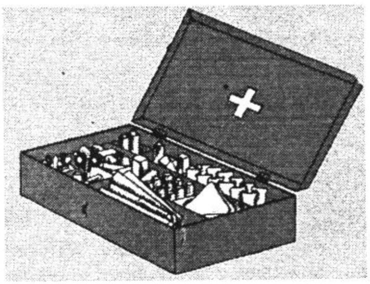
1 NEED OF THE FIRST AID

Prevention is better than cure but when prevention is not possible and an injury does take place, cure is the only prevention of further injury and this cure is primarily to be provided by the First Aid.

First Aid can be defined as an immediate treatment given to the victim of an accident or sudden illness, before -medical help is obtained. It is a combination of simple but quite expedient, active measures to save the victim's life and prevent possible complications. It needs to be immediate in severe accidents complicated by bleeding, shock and loss of consciousness.

See tables in Part 12 of Chapter-5 for statistics of accidents in India and Gujarat. It is evident that majority of these accidents are trifle and curable by first aid only. Even otherwise all industrial injuries need immediate first aid for which statutory provisions are also made as follows.

2 STATUTORY PROVISIONS



Section 45 of the Factories Act requires at least one first aid box or cupboard equipped with the prescribed contents for every 150 workers employed at any one time. It should be readily accessible during all working hours and should be in the charge of a qualified person.

For a factory employing more than 500 workers an ambulance room of the prescribed size and contents and in the charge of medical and nursing staff is also required.

Rule 70 of the Gujarat Factories Rules prescribes the contents of a first aid box depending upon the number of persons employed. Rule 70A requires a displayed staling the names and place of availability of the first aider, nearest hospital and its telephone number. Rule 71 prescribes the. size and other details for an ambulance room or dispensary, a suitable conveyance to remove the victim and a record of all cases treated. Refer these rules for the medical items to be kept ready.

See Chapter-24 for Section 41C and Rules 68 R, T, U & V of the Gujarat Factories Rules for Health Records, Medical examinations. Occupational Health Centre, Ambulance Van etc.

3 INDIAN STANDARDS

A few IS available for first aid are: First aid dressings 11163, pesticide poisoning 4015, radiation protection in medical X-ray equipment of 10 KV to 400 KV 7064, Colour identification of gas cylinders for medical use 3933.

Bandage cotton 863, plaster of Paris 4738, 6237, scissors 6252,10384.

Resuscitators for use with humans 13366:

4 GENERAL PRINCIPLES FOR RENDERING FIRST AID

4.1 Meaning :

First Aid has five main aims : -

1. To preserve life.
2. To promote or assist recovery.
3. To prevent worsening or aggravation of the casualty's condition.
4. To minimise complication and
5. To arrange transportation to hospital if necessary.

First Aid is based on scientific medicine and surgery. It is a skilled assistance and makes use of such materials as may be available. But the first aider is not a Doctor. After the doctor takes charge, the first aider's responsibility ends. He can then stand by to help the doctor.

The first aider should observe carefully, think clearly and act quickly. He should be calm, cool and confident. He should not get excited. He should ask someone to call a doctor/inform hospital immediately giving some details of cases involved. While waiting for the doctor, he should give first aid methodically.

Dr. Y. N.Sinha, Dy. Director (Medical) of CLI, Mumbai explains the general meaning of FIRST AID

1. First thing first.
2. Inform the doctor.
3. Reassure the victim.

4. Shock prevention or treatment.
5. Tourniquet, control bleeding.
6. Artificial respiration.
7. Immobilise fracture.
8. Disposal, send victim to hospital.

4.2 General Rules

The general rules or principles for first aid are as follows :

1. Reach the accident spot quickly. This will help to save life.
2. Be calm, methodical and quick. By doing so you can lessen the pain and the effects of the injuries which may save life. Handling the casualty clumsily will only make the final recovery difficult.
3. Look for the following: Is there failure of breathing? Is there severe bleeding? Is the shock light or severe?
   (1) Attend to these and then treat easily observable injuries.
   (2) Start artificial respiration, if the casualty is not breathing. It must being at once as every second gained is helpful.
   (3) Stop by pressing on the pressure point and press firmly on the bleeding area with a pad and keep up pressing on the bleeding area for at least a few minutes (minimum 3 minutes) by watch. Take help if needed.
   (4) Treat for shock.
   (5) Avoid handling the casualty unnecessarily.

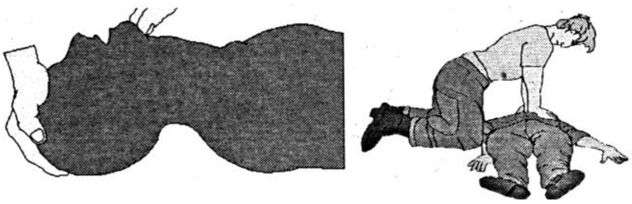
4. **Priority of Treatment** by a first aider should proceed in the following order :
   1 Examination and Diagnosis.
   2 Cardio Pulmonary Resuscitation (every second counts).
   3 Control Bleeding.
   4 Treat Shock and special care of Unconscious cases.
   5 Fracture (Immobilisation).
   6 Burn-Cover with clear washed cloth/ dressing and treat shock.
   7. Eye, Nose and Ear injuries.
   8. Multiple superficial injuries.
   9. Transportation and
   10. Follow up or After-care.

5. Dr. Subhash Mhaskar (Thane) suggests following formula for basic assessment of a serious case -

DR. ABC & Head-Foot Examination :

D = Danger. Please check up first, if there is any sort of danger to the first aider or the patient or to the people around at the 'spot of the accident in form of poisonous gas, electric current, fire etc.

R = Response. Call the patient by his name or pinch him and see the response. If no



response, the patient is unconscious. Then immediately -

(A) = Open the Airway by flitting his head to the back and chin up.
(B) = Check Breathing
(C) = Check Circulation of blood by checking neck pulse. If the patient is not breathing but the neck pulse is present, give mouth to mouth breathing only. If neck pulse and breathing both absent start CPR (Cardio Pulmonary Resuscitation)

Head Foot Exam = If both neck pulse and breathing are present and patient is responding, continue with head to foot examination. Look for injuries bleeding and fractures systematically. Specially look for injuries on head, chest and abdomen. They may not look important in beginning but may prove to be fatal in long term.

6. Use the First Aid equipment, if available. All passenger trains, some Railway Stations, lorries and buses keep them. Make use of the material so obtained. On most occasions standard First' Aid equipment will not be available. You will have to depend on the material at hand and improvise them for your requirements.- In a factory, use the prescribed first aid box.

7. Inspect the area. Take the casualty away from live wires, fallen walls, beams, fire, broken gas chambers, moving machinery etc. to a safer place.

8. Clear the crowd with nice words. Do not allow people to crowd around the casualty. The casualty needs fresh air. If a doctor is present, he will guide you. Any other First Aider must be asked to help. Otherwise take the assistance of bystanders giving them correct instructions.

9. Note the weather. If it is fine, i.e. without rain or heat or a cold breeze, treat in the open. Otherwise move the casualty into an airy room. If no suitable house or a doctor's clinic is not nearby, it is best to protect the casualty with an umbrella or a sheet of cloth or even a newspaper.

10. Reassure, the casualty. Soft words and encouraging talk will make the casualty take things easy and lie quietly. These will help recovery.

11. Arrange for dispatch to the care of a doctor or to the Hospital. At the same time intimate the relatives where the casualty is being taken to.

12. Do not attempt too much. You are only a First Aider. Give minimum assistance so that the condition does not become worse and life can be saved.

The first aider should know the proper use of antiseptic, aseptic and sterilised dressing material, surgical instruments and syringes. Some commonly used chemical antisepsis (to kill micro organisms in the wound) are: Hydrogen peroxide solution. Potassium permanganate. Boric acid. Tincture of Iodine, lodinate, lodoform, Chloramine B, Mercuric chloride. Dioxide, CoUargol, Silver nitrate. Spirit (ethanol). Brilliant green solution, Methylene blue solution, Degmin, Ethacrdidme lactate, Furacilin, Ammonium hydroxide solution, pure- phenol (carbolic acid). Formaldehyde solution and Sulphonamides.

4.3 Ten commandments :

Dr. Subhash Mhaskar of Thane has highlighted in his small pocket-book, the ten commandments of First Aid as under :

1. You shall always try to help the casualty to the best of your knowledge and with sympathy.
2. Never give anything by month to an unconscious patient.
3. Always keep unconscious patient in recovery position.
4. Always look for the breathing and pulse. If it stops, start CPR (Cardio Pulmonary Resuscitation) without any loss of time.
5. In an unconscious patient with poisoning, never induce vomiting.
6. Do not add haldi, chuna or any other thing in a wound
7. In poisonous snake bite, tie a tight bandage before everything and do not release it till the patient is taken to a doctor. Bandage should not block arterial circulation.
8. When neck spine fracture is suspected, absolutely do not allow to move the neck. It can cause instant death.
9. Do not give CPR to a conscious patient.
10. Always take the patient to a doctor. Do not try to take place of a doctor.

Semi or fully automatic external defibrillator should be provided at all prime places, factories, OHC, medical centres etc. It is most useful in cases of cardiac toxicity and sudden heart arrest.

5 INJURIES AND FIRST AID AT A GLANCE

Injuries may be as follows:

The victim may be pinned down under the machinery. There may be lacerations; a part of a limb may be avulsed, there may be multiple fractures of severe traumatic shock. In some cases, it is not possible to extricate or release the victim. In such cases, the machinery should be stopped immediately, power cut off and services of senior forman or the person who is familiar with the machine, requisitioned. Modern machines have automatic releasing devices or you may have to dismantle the parts. The first aider is to attend the victim, control the bleeding, treat shock, reassure and cover any burnt or injured part. If the victim is unconscious ensure that the air way is clear. Arrange for immediate medical aid at the spot and remove to the hospital.

Burns due to chemicals or hot substances, cuts, wounds, shocks, bleeding, unconsciousness, poisoning and casualty may also happen which should be properly approached.

Some typical injuries and first aid for them are briefly described below to study them at a glance.

Shock:

1. Lay the patient on his back. Lower head end.
2. Stop bleeding if any. Stop pain in burns by pouring cold water.
3. Relieve pain by supporting injured part.
4. Keep the patient comfortable, but not hot. Do not cause sweating.
5. Make the air passage clear and clean.
6. Fluids may be given in small amounts unless the patient, is nauseated, unconscious, likely to be operated on, or has an abdominal wound.
7. Reassure and cheer up the patient.

Electric Shock :

1. Separate the patient from electric current by proper technique. Stop the switch or use wooden stick for separation.

2. Make a rapid examination to ensure that the air passages are free. Clean them if necessary,
3. Restore natural breathing by artificial respiration, if breathing has ceased.

Wounds :

1. Stop the bleeding by any one of the following methods :
   (1) Direct pressure.
   (2) Direct finger pressure into the wound in case of larger bleeding wound.
   (3) Tourniquet (seldom needed) use only as a last resort.

2. Avoid touching the wound with hands or unsterile material.

3. Clear the wound with running water and surrounding area with soap or spirit with clear gauze washing away from the wound. Apply ready-made adhesive gauze bandage or sterile gauze and roller bandage as needed.
4. Keep the patient quiet; raising the extremity if it is the bleeding part. Give no stimulants.
5. Never apply antiseptic ointment, lotion or iodine or germicide to the wound.
6. Elevate injured part above the patient's heart level.
7. Try and use rubber gloves.

Abdominal wounds:

1. No time must be lost in sending the patient, to the hospital.
2. Keep the patient flat.
3. Give nothing by mouth.
4. Maintain warmth.
5. If. intestines protrude from the wound do not attempt to touch or replace them.
6. Apply sterile dressing and binder as for wounds.
7. Provide careful and immediate transportation to the hospital.

Eye-Wounds:

1. Removal may be attempted if foreign body is not embedded.
2. Do not apply- oil or ointment.
3. If there is a foreign body embedded in the eye ball, send the patient immediately to the doctor after applying pad and loose bandage.

Chemical Burns of the Eyes :

1. Immediate washing of the eye at least for fifteen minutes is of great importance.
2. Apply sterile bandage and send the patient immediately to the doctor.
3. Neutralising agent or ointment should not be used.

Suffocation :

1. Remove the patient from the source of danger.
2. Make a rapid examination to ensure that the air passages are free and to clean them if necessary.
3. Restore natural breathing by artificial respiration, if breathing has ceased.

Infection :

1. Wash hands with soap and water.
2. Use diluted antiseptic like diluted dettol.
3. Cover the wound with sterilised bandage or clean cloth.
4. Do not tighten the bandage excessively.
5. Do not apply haldi, lime etc. on wound.

Heat stroke :

1. Make the patient lie down.
2. Remove all clothing except underwear.
3. Pour cold water on the head and body.
4. Keep the patient under the fan.
5. Record temperature every 10 minutes and when it falls up to 30 °C, stop pouring water and clean the head and body with towel.
6. Give plenty of cold water with a spoonful of common salt in a glass of water to drink.

Bleeding Nose :

1. Make the patient sit with head downward.
2. Pinch the nose with fingers and thumb.
3. Apply ice or cold compressing or pour cold water on head.
4. Do not plug the nostrils.
5. Do not put water or any medicine through the nostrils.
6. Send for medical attention.

Bleeding Ear :

1. Lay the patient with head slightly raised.
2. Incline the head to the affected side and apply a dry dressing over the ear with loose bandage.
3. Do not plug the ear.
4. Apply pressure in front of the ear.
5. Seek medical attention.

Insensibility:

1. Send for a doctor. Meanwhile do the following:
2. Where the patient's face is pale, lay him flat and face downwards with his head turned to one side. If his face is flushed or blue, raise and support the head and shoulders.
3. Control any serious bleeding.
4. Loosen any tight clothing and let him have plenty of air.
5. Do not give anything by mouth.
6. If doctor is not available send the casualty to hospital.

Heart Attack :

It is very important that the heart attack patient reach hospital in first 2 hours.

The important symptoms of Heart Attack are:

1. Symptoms (3Ps) :

(1) Pain in chest: In the centre of the chest radiating to left arm, jaw or left shoulder. The pain is consisting, severe and lasts for more than 5 minutes. Although pain is an important symptom, there can be painless hpart aH-ark alun
(2) Perspiration: Sudden, severe perspiration without cause.
(3) Palpitation : Without exertion.

2. Sudden vomiting with gases like symptom but with restlessness and perspiration.
3. Sudden breathlessness.

In case of mild heart attack

1. Stop all activities of patient.
2. If available keep Sorbitrate tablet under the tongue of the patient.
3. Give half Aspirin tablet.
4. Watch for pulse and breath.
5. Contact doctor immediately.

In case patient becomes unconscious and breathing and neck pulse stops, immediately call for help and start C.P.R. as per instructions.

Epilepsy :

1. Open the airway.
2. Prevent tongue biting.
3. Keep the patient in recovery position till consciousness.

Bruises :

1. Cold applications at first 24 - 48 hours.
2. Later heat after 24 - 48 hours.

Burns :

1. Act quickly.
2. Put the affected part in cold water.
3. Pour water on burns that cannot be immersed (Cold water relieves pain, reduces fluid loss).
4. Cover with a sterilised dressing.

Dog Bite :

1. Wash the wound immediately with water or dettol.
2. Do not try to stop bleeding.
3. Cover the wound with a sterile dressing.
4. Send the patient to hospital.
5. Watch the dog for 10 days.

Snake Bite :

1. Advice patient not to panic and run.
2. Without delay tie a band or handkerchief tightly 2-4 inches above the bitten part. However, you should feel pulse below the bitten part.
3. Lower the bitten part below the heart.

4. Wash the bitten part with clean water.
5. Examine the pulse and respiration.
6. Carry the patient to hospital for antisnake venom injection.
7. If possible cut at the wound with a snake bite insect, knife or a sharp instrument to allow free bleeding.
8. Never suck the blood from the wound.

Unconsciousness or Coma :

Main cause - Head injury, brain diseases, poisoning, asphyxia, heart attack.

Treatment:

C : Call for help. Lie down the patient in prone position.
O : Observe patient's breathing, heart beat and pulse.
M : Maintain recovery position. Loosen tight clothing. Clean the air way. Give artificial respiration or external cardiac massage.
A : Absolutely nothing by mouth. Arrange for transport to hospital immediately.

6 FIRST AID IN MINOR AND CLOSED INJURIES

6.1 Minor Injuries :

Minor injuries (cuts, punctures, abrasions, scratches, splinters) are frequent in everyday life. In themselves they are not dangerous and do not cause loss of working, ability but when first aid is not properly rendered they can be complicated by purulent inflammation.

Any break in the skin, even in minor injury, should be painted immediately with a 5 per cent iodine tincture and covered with an aseptic bandage. If skin and wound are contaminated, the skin around the wound should be wiped with 0.5 per cent ammonium hydroxide and the wound with 3 per cent hydrogen peroxide. When the edges of the wound are smooth and even but the wound is wider than 0.5 cm its edges should be brought together. For that purpose a piece of adhesive plaster shorter than the wound is cut from a strip and one end .is stuck across one edge of the wound to the skin, the opposite edge of the wound is brought close and fixed by the other end of the plaster. The plaster should not wholly cover the wound, and its ends should be left uncovered. An aseptic bandage is then applied to the wound over the plaster. Minor wounds and abrasions are covered by colloid or a special glue.

It is desirable to cover punctured wounds with a spirit bandage.

With contusion of the fingers or toes there is often bleeding beneath the nails that later can suppurate and cause acute inflammation. To prevent this complication it is necessary for a doctor to release the blood accumulated under the nail and apply a spirit bandage. The procedure is simple and does not require anaesthesia. When foreign bodies (clearly visible metallic needles, filings or chips, splinters of wood etc.) penetrate the skin they should be removed by tweezers, the wound painted with iodine tincture and a spirit bandage applied.

6.2 Closed Injuries :

Closed traumas are mechanical injuries in which the skin and mucous membranes are not broken. They include contusions of various parts of the body (and. the skull and brain), strained ligaments, dislocations, subcutaneous rupture of the muscles, internal organs of the chest and abdomen and bone fractures.

Bruises and contusions may be caused by a blow from a blunt object or by falling. The signs include pain at the site of the injury and the development of a bruise which becomes bluish in a few days.

First Aid: In order to lessen the pain and to prevent bleeding the contused area should be immobilised, raised and cooled by applying an ice bag or acold compress. The cold contracts the blood vessels and reduces bleeding. Two or three days after the bruise warmth should be applied to accelerate resolution of the effused blood (hot compresses, local warm baths).

A hot compress (fomentation) is made as follows: A folded pad of cloth is soaked in water, an 8 per cent solution of surgical spirit or camphor oil, wrung out and applied to the skin. An oilskin or waxed paper of a larger size (two or three centimetres larger than the compress) is laid over it and the whole is covered by a thick layer of cotton wool and secured with a roller bandage. The compress is left for six to eight hours, during which the moist layer dries. After the compress is removed the skin is wiped with alcohol.

Sprains of ligaments are frequent. An awkward movement wrenches joint or a. slip overextends a joint which causes some degree of tearing of the joint capsule or ligaments. Pain and swelling develop around the joint but its outlines are generally not noticeably altered. The victim can use his limb, but with difficulty. Put weight on the foot or move the painful arm. After a few days the skin becomes black and blue.

First aid : The affected limb should be immobilised (an arm put in a sling made from a triangular bandage and affected ankle tightly bandaged),. After two or three days, treatment is begun (hot compresses, local warm baths and massage). '

A dislocation is a more serious injury attended with rupture of the joint capsule and displacement of the joint surfaces of the articulated bones.

First aid : A fixing bandage or a splint is applied and the patient sent to hospital for the dislocation to be reset.

6.3 Fractures :

It may be open or closed. Open fractures in which not only the bone but also the skin are damaged are most dangerous. Germs can get into die wound formed by the break in the skin and cause suppuration gas gangrene or tetanus. In closed fractures the outer coverings (skin and mucous membranes) are intact and prevent the entry of germs.

The signs of fractures of the long tubular bones include pain, haemorrhage, distortion of the injured part of the arm or leg, abnormal mobility in a place where there should be none, crackling, swelling, deformity and inability to make any movement.

The fragments of the bone may be displaced to a varying degree in length, width, or at an angle to each other causing some deformation of the limb.

First Aid ; The limb affected must be immobilised. This is especially important during transportation of the patient. The bone fragments should be tied so that they cannot move. The rules for immobilising fractures should be observed. If they are not observed, grave complications can develoi menacing the patient's life.

Treatment:

1. Immobilise the fractured limb with splint like wooden stick, hardboard or umbrella
2. Make a padding of cotton or hanky on the splints.
3. Do not tighten the splint too tight or loose
4. Elevate the injured limb.
5. Use natural splints, like if a leg is fractured the other leg can be used as natural splint.

Spine Fracture:
Falling from height can cause spine fracture

Treatment:
Move the patient on a hard surface like table or bench etc.

1. Do not allow to sit, stand or walk
2. Tarn the patient by log rolling
3. Shift the patient to hospital.

Backbone (Spinal) Fracture:

1. Transport on a rigid frame. This frame may be improvised by using available boards or a door.
2. The rigid frame may be placed on a stretcher for transportation.
3. If a firm frame cannot be improvised, transport patient on abdomen on a stretcher made of canvas or blanket.
4. In neck fracture cases it is much better to get a doctor to the scene because danger to the life is great.
5. Immediate hospitalisation is necessary.

6.4 Foreign Body in the Body Part :

6.4.1 Foreign Body under the Skin :

Thorns, glass, iron, pieces, needles, etc., get under the skin.

First Aid:

1. Unless very easy to deal with, don't interfere.
2. Dress the wound.
3. Immobilise the part with splints and get medical aid.

6.4.2 Foreign Body in the Eye :

Wings of insects, dust, coal (from boilers -etc.), metal particles from lathes and loose eye-lashes are 1. common objects which get lodged under the eyelids. They cause pain and later redness, if they are not removed at once. Sometimes iron particles and wood splinters get lodged in the corner causing serious trouble. Penetrating foreign bodies, however are danger to the eye itself.

First Aid:

1. Avoid rubbing the eyes. In case of a child, tie his hands at the back.
2. Seat the casualty so that light falls on the eye. Pull the lower lid down. If the foreign body is floating and not embedded, remove it with a narrow, moist swab. The corner of a handkerchief twisted to a fine point will also do.
3. If foreign body is not visible it may be under the -upper eye-lid. Ask the casualty to keep clean water in the hand and blink briskly in the water. If unsuccessful, pull the upper lid forward, push the lower lid upwards and let go of both the lids. The lashes of lower lid usually dislodge the foreign body. Try this two or three times.
4. If the foreign body is embedded in the eye, particularly the cornea (the black of the eye) do not touch it—apply a soft pad, bandage the eye, ask the casualty not to rub the eye and take him immediately to a hospital.
5. Penetrating foreign bodies are easily made out by bleeding, pain etc. It is for the doctor to handle. You just put a pad bandage.
6. When corrosive acid, alkali or juices from plants are suspected, blinking eyelids under water a number of times or flushing with large quantity of water is the best thing to do. Then apply a soft pad, tie a bandage (not tightly) and take the casualty to the hospital at once.

6.4.3 Foreign body in the Ear :

1. If it is insect, fill the ear with glycerine or coconut/mustard oil or warm salt water. The insect will float up and can be removed easily.
2. If there is nothing floating up, leave it alone, don't meddle at all but take him to a doctor.
3. If it is solid, do not try to remove, scratch or probe it. Take him to a doctor.

6.4.4 Foreign Body in the Nose :

1. Do not interfere with the foreign body.
2. Make casualty breathe through the mouth.
3. Take him to the hospital. If a child, tie the hands behind so that he does not interfere with the foreign body.

6.4.5 Foreign Body in the Throat :

1. Some small objects like a safety pin sometimes get stuck in the throat. A draught of water is all that is needed to pass it further down.

2. Some irregular objects, fairly large, get stuck. If visible they can be taken out with the fingers. If a child, hold it up, head downwards and tap on back of neck, the foreign body will fall out.

3. Fish-bone or thorn get lodged by piercing some part of the throat. Keep the relatives and the casualty quiet and remove the casualty to the hospital at once.

6.4.6 Foreign Body in the 'Stomach :

Smooth objects like coins, buttons, nuts, safety pins are swallowed.

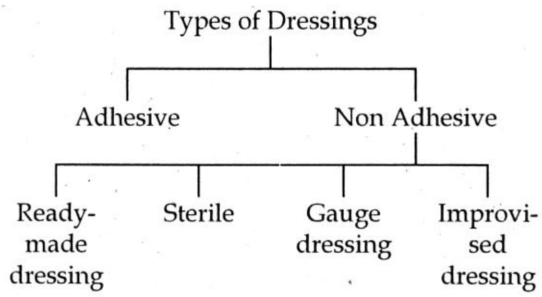
1. The stomach and intestines will adjust themselves in such a way as to throw them out.
2. Do not panic.
3. Show the case to a doctor.
4. There is no need to give laxatives (or bananas as is usually done).

6.5 Dressing & Bandaging :

A dressing is a protective covering applied to a wound to

1. Prevent infection.
2. Absorb discharge.
3. Control bleeding and
4. Avoid further injury.

An effective dressing 'should be sterile (germ-free) and porous to allow for oozing and sweating.



Dressing should be applied gently after washing hands thoroughly. No part of the wound or dressing to be contacted should be touched by fingers. Dressing must be covered with adequate pads of cotton wool, extending well beyond them and retained in position by a bandage or strapping.

Bandages are made from cotton cloth, elastic net or special paper and are used to (1) retain dressings and slings in position (2) maintain direct pressure over a dressing to control bleeding (3) prevent or reduce swelling (4) provide support for a limb or joint (5) restrict movement and (6) assist in lifting and carrying casualties.

Bandages should not be too loose or too tight. A bluish body part or loss of sensation indicates too much tightening.

Bandages are of two types - Triangular and Roller bandages.

A triangular bandage is made by cutting a square piece of cloth 100 cm~ from corner to corner so as to give two bandages. A triangular bandage can be used (1) as a whole cloth spread out fully and (2) as a narrow bandage by folding to the required size. For tying the bandage a 'reef knot' should be used and not a 'granny knot' which is likely to become loose.

There are systematic methods of bandaging with the triangular or roller bandages.

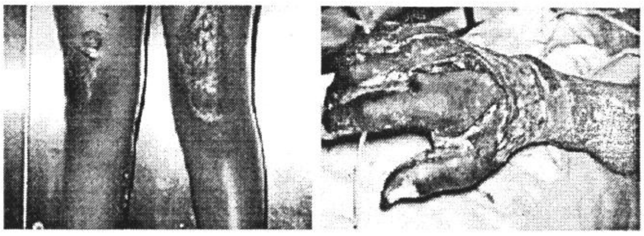
Triangular bandages can be used for scalp, forehead, eye, cheek, front or back of the chest, shoulder, elbow, hand, hip or groin, knee, foot and stump.

Roller bandages are made of cotton with loose mesh, are of various lengths and widths and are used in hospitals and first aid posts. Roller bandages should be applied firmly and evenly. There are 4 methods to apply roller bandages (1) Simple spiral (2) The reverse spiral (3) Figure of Eight and (4) The Spica.

See Reference No. I for details of various techniques of above bandaging.

7 ELECTRICAL INJURIES

Causes of Electrical Injuries : If any part of the body comes in contact with a "live" wire which is exposed and not covered by insulator, or with a cable or rail in which current is leaking , a person gets an electric shock.. In houses, the blowing out of switches or fuses or faulty electrical connections can cause such injury. The injury may be quite mild or so severe as to cause immediate death. Electrical shock is produced only when an electric current passes through the human body which is in contact With earth. It passes even more quickly if the part is wet.



In wet conditions even lower voltage may be dangerous. A very strong current passing to earth through lower limbs may be less dangerous than a weaker current passing through the chest, especially so when it enters through the hands and arms.

The Effect of Electric Shock .

1. There may be fatal paralysis of heart.
2. There may be sudden stoppage of breathing due to paralysis of muscles used in breathing.
3. Heart may continue to beat, while breathing has stopped. In this condition the face appears blue.
4. There may be burns, either superficial or deep. They depend on the strength of the electric current causing the injuries.

First Aid: Intelligent and prompt action is required. If the first aider is not cautious, he may also receive severe electric shock or even die along with the casualty.

1. If the casualty is still in contact with the conductor, switch off the current. If the switch is not found, remove the plug or cut off the current by breaking the wire, ensure that you stand on a dry piece of wooden board. Do not use scissors or knife. Wooden handle is unsafe above 380 V. When the current is of low voltage the first aider should stand on an insulated material which is dry. (Insulating materials are rubber-soled shoes, wooden plank or piles of newspaper). High voltage rubber gloves should be worn. If not, dry coat, cap or other clothing may be used. When the current is of a very high voltage, as in the case of over head (high tension) lines, there is greater danger. The casualty may not be in actual contact with the wire as the current can pass through the gap (causing an arc). The first aider in such circumstances should keep as far away as possible from the electric wires. The casualty is to be dragged out by means of a non conducting material. A walking stick, dry bamboo pole, wooden plank or a dry rope is to be used.

2. If the casualty is not breathing normally, or heart has stopped beating, open his clothes, unbutton the collar, loosen the belt, give artificial respiration and external cardiac massage for a long time.

3. Treat for shock.

4. Treat for burns if any.

5. Transfer to a hospital or seek the help of a medical practitioner who is nearest.

6. Even when the casualty has recovered fairly well after first aid is given, he must be examined by a medical specialist because electric injuries are liable to relapse.

For electrical safety see Chapter-11.

8 ARTIFICIAL RESPIRATION

Treatment when not breathing:

1. Loosen all clothing at waist, chest and neck.
2. Tilt the head backwards, while supporting the back of neck with your palm. This will lift the tongue to its normal position. Thus the air passage will be cleared and the casualty may begin to breath after a gasp.
3. If breathing does not begin after the above treatment, help movements of chest and lungs four or five times. This will be usually enough to start breathing. If breathing does not start even now, mouth to mouth (-to-nose) breathing should be begun.

Mouth-to-Mouth breathing:

1. Place the casualty on his back. Hold his head tilted back.
2. Take a deep breath with mouth open widely.
3. Keep nostrils of casually pinched.
4. Cover the mouth of the casualty with your mouth smugly.
5. Watching the chest, blow into his lungs, until the chest bellows up. Withdraw your mouth. Note the chest falls back (It is hygienic to cover the mouth of casualty with your handkerchief or some clean cloth).
6. Repeat the above 15 to 20 times a minute.
7. If casualty is young (baby or child) the operations are as above, but your open mouth should cover both the mouth and nose of the casualty and blow gently.
8. If the chest does not rise (as in 5 above) look for an obstruction.
   - Turn the casualty to a side and thump his back. This will make the obstructing material come to the front of throat. Open the mouth and remove it with your finger covered with a piece of the cloth.
   - If a child, hold it up by the feet and thump the back.
9. Use mouth-to-nose respiration if mouth to-mouth is not possible, but now the casualty's mouth should be closed by the First Aider's thumb.
10. If heart is working, continue artificial respiration until normal breathing occurs. Send for Ambulance.
11. If the heart is not working, you will notice:

    - The face is blue or pale.
    - Pupils are dilated.
    - Heart beats and pulse at the root of neck (carotid) are not felt.

Then treat as follows: (a) Place the casualty flat on his back on a hard surface (bench, table etc.) (b) Give a smart hit with the edge of your hand on the lower and left angle of the sternum. This usually stimulates the heart to work. (c) In case the heart does not work, persist the striking for 10-15 seconds at the rate of one stroke a second. Feel for the pulse at the root of neck all the time. If the pulse becomes regular and continuous, stop beating, all the while artificial respiration has to go on.

Even if the casualty is breathing, but the breathing is not normal, it is wise to start artificial respiration. Do not begin thumping the heart or compression until you are sure that the heart has stopped beating.

External Heart Compression :

(If there are two trained persons) :

1. This should go on along with artificial respiration. Therefore ask the First Aider giving mouth-to-mouth breathing to sit to the right of the casualty and place yourself on the left side.

2. Feel and mark the lower part of the sternum.

3. Place the heel of your hand on the marked part (make sure that the palm and fingers are not in contact with the chest).

4. Place the heel of the other hand over it.

5. With your right arm, press the sternum backwards, towards the spine. (It can be pressed back 1 to 1.5 inches in adults).

6. Adults should be given about 60 pressures a minute. For children from two to ten years 3 pressures with one hand (heel) will be enough, but pressure should be 80 to 90 times a minute. For babies up to two years, 2 pressures with two fingers is good enough if applied 100 times per " minute.

7. Press firmly but carefully. Carelessness (over pressure) may cause injury to ribs and deeper tissues.

8. If the treatment is effective (a) Colour will become normal (b) Pupil will contract as improvement beings; and (c) Carotid pulse begins with each pressure.

9. When pulse is not restored, continue compression till the patient reaches hospital.

10. Inflation of lungs to heart pressure should be as 2.15. If there is only one First Aider, he has to be very smart and active. Finish 15 heart compression, rush to head-side, give two inflation to the lungs, and get back to the heart and give 15 compression. Repeat these. If there are two First Aiders, No. 1 makes 5 heart compression and then No. 2 gives two lungs inflation. These are repeated. At the same time No. 1 can watch the pupils and No. 2 can feel the carotid pulse.

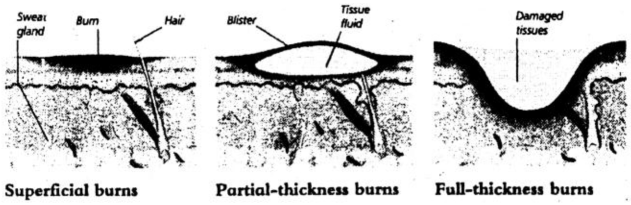
9 BURNS AND SCALDS

Causes of Burns and Scalds :

1. Burns are injuries that result from dry heat like fire, flame, a piece of hot metal, the sun, contact with wire carrying high tension electric current or by lightning or friction. Scalds are caused by moist heat due to boiling water, steam, oil, hot tar etc.
2. Chemical burns are caused by strong acids (Sulphuric acid. Nitric acid etc.) or by strong Alkalis (Caustic Soda, Caustic Potash, quick lime or strong Ammonia).

3. A nuclear burn is caused by the instantaneous flash of intense heat given off by a nuclear explosion. It is capable of causing superficial burns on the exposed skin of persons several miles away.

Degrees or Depth of Burns :

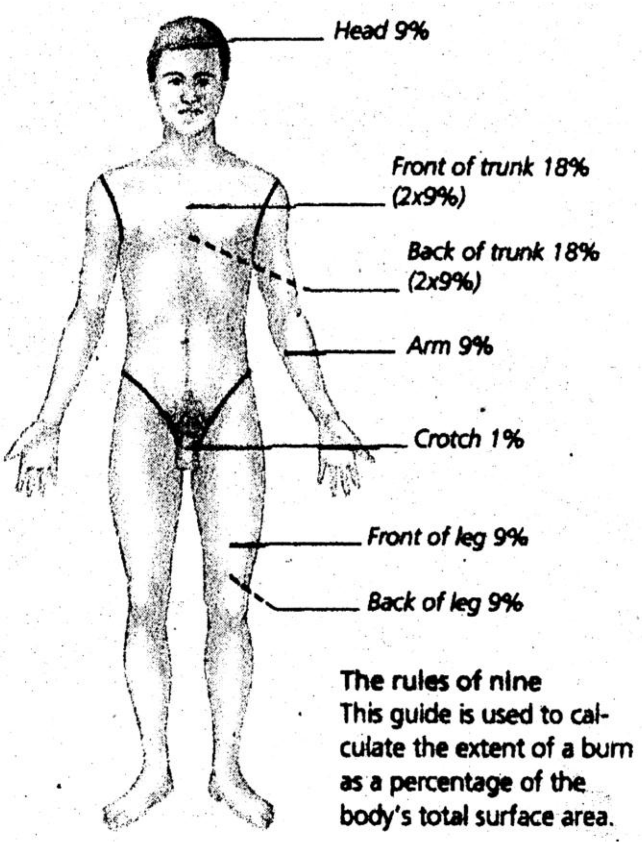


The degrees of burns indicate the degree of damage to the tissues. There are five degrees of burns:

First Degree : When the skin is reddened
Second Degree : When there are blisters on the skin, and
Third Degree : When there is destruction of deeper tissues and of charring.
Fourth Degree : Steam blebs
Fifth Degree : Carbonisation

Percentage of Burn :

The danger from burns depends on the area i.e. percentage of the body part of the burns rather than



the degree. Superficial burns over a large area of the body are more dangerous than the complete carrying of a part of the limb. It must be noted that in the same person, different parts of the body may show different degrees of burns. Any burn of over 30% irrespective of deep degree - should be hospitalised as priority. More than 50% burns are more serious.

Above figure shows the percentage (extent) of burns. It follows the rule of 9. For more area, add the percentage appropriately. For example, burns of both hands and both legs indicate 9+18 = 27% burns.

Helping a person whose clothes have caught fire :

The First Aider should know how to deal with a person whose clothes have caught fire.

1. Put out the flames by whatever means available. Most of the causes of burns occur in homes and drinking water is readily available to quench the flames, water also cool the burnt area causing less damage to occur.
2. Do not allow the person to run about. This only fans the fire and makes the flames spread.
3. Hold a rug, blanket, coat or table cover in front of you, while approaching a man whose clothing have caught fire.
4. Lay him down quickly on the ground and wrap tightly with any thick piece of cloth, rug or coat. Smother the flame by gently rolling the causality or by gentle pats over the covering.
5. If the clothes in front of the body have caught fire, lay him on his back and vice versa, till suitable material is brought to smother the flame.

Rescuing Persons from Fire:

1. In rescuing persons from a room which has caught fire, quick and clear thinking is required.
2. Remember clean air is at ground level. So crawl along the floor to pull out a person who is lying unconscious or is disabled.
3. Have a wet kerchief round your face when you go for rescue.
4. If there is carbon monoxide in the room, these precautions do not protect the rescuer from carbon monoxide poisoning. When there is fire in a closed room, there is always some amount of carbon monoxide, therefore quick action is all important.
5. When there is fire in a room in which the doors and windows are closed, do not open the windows and door to let in air. The rush of air will increase the fire and it will burn more intensely.

First Aid of minor Burns and Scalds:

In the case of minor burns:

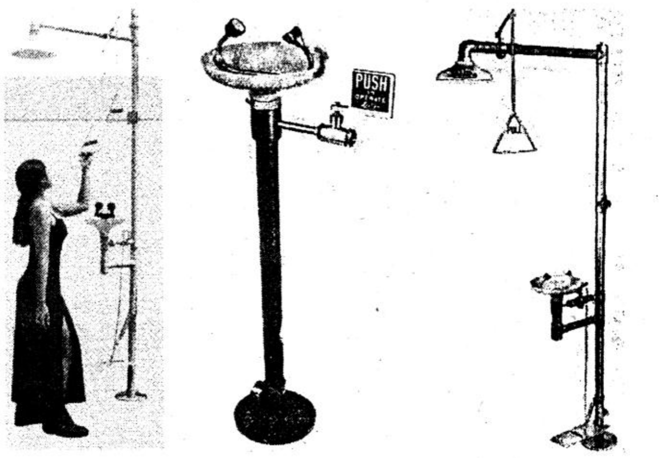
1. Clean the area gently with clean water.
2. Submerge the burned area in cold water.
3. Apply a solution of salt and water (one teaspoonful to a pint of water) in out of the way places.
4. Cover with dry dressing.
5. Do not apply cotton wool direct to the burnt.
6. Do not apply any greasy substance.
7. Give warm drinks for example sweetened tea or coffee.

First Aid of Serious Burns and Scalds :

Immediate attention that required in serious burns are:

1. Keep the casualty quiet and reassure him.
2. Wrap him up in clean cloth.
3. Do not remove adhering particles of charred clothing.
4. Cover burnt area with sterile or clean dressing and bandage. In case of burns covering a large part of the body, it is sufficient to cover the area with a clean sheet or towel.
5. Keep him warm but do not overheat him.
6. If the hands are involved, keep them above the level of the victim's heart.
7. Keep burned feet or legs elevated.
8. If victim's face is burnt, sit up or prop him up and keep him under continuous observation for breathing difficulty. If respiratory problems develop, an open airway must be maintained.
9. Do not immerse the extensive burned area or apply ice-water over it because cold may intensify the shock reaction. However, a cold pack may be applied to the face or to the hands or feet.
10. Shift the casualty to the nearest hospital if he is fit to be moved.
11. If you cannot take him to a hospital, wait for the doctor to arrive.
12. Do not open blisters.
13. Keep him wrapped up in clean cloth.
14. Treat for shock.
15. Remove quickly from the body anything of a constricting nature like rings, bangles, belt and boots. If this is not done early, it would be difficult to remove them later as the limb begins to swell.
16. If medical help or trained ambulance personnel cannot reach the scene for an hour or more and the victim is conscious and not vomiting give him a weak solution of salt and soda at home and enroute :- One level tea-spoonful of salt and half level tea-spoonful of baking soda to each quart of water, neither hot not cold. Allow the casualty to sip slowly. Give above four ounces to adult over a period of 15 minutes: two ounces to a child between I and 12 years of age and about one. ounce to an infant under one year of age. Discontinue fluid if vomiting occurs. Do not apply ointment or any form of grease or other home remedy.

First Aid of Chemical Burns :



1. Wash off the chemical with a large quantity of water for 15 minutes by using a shower or hose if available as quickly as possible. This flooding with water will wash away most of the irritant.
2. Cut out contaminated clothing.
3. Do not touch.
4. Treat as for burns.

Burns of the Eye :

Acid Burns:

1. First aid for acid burns of the eye should be given as quickly as possible by thoroughly washing the face, eyelids and the eye for at least fifteen minutes by water.
2. If the casualty is lying down, turn his head to the side, hold the eyelids open and pour water from the inner corner of the eye outward. Make sure that the chemical does not enter into the other eye. Cover the eye with a dry, clean protective dressing (do not use cotton) and bandage.
3. Neutralising agents or ointments should not be used.
4. Caution the victim against rubbing his eye.
5. Get medical help immediately (preferably an eye specialist).

Alkali Burns:

Alkali burns of the eye can be caused by drain cleaner or other cleaning solution. An eye that first appears to have only a slight surface injury may develop deep inflammation and tissue destruction and the sight may be lost.

1. Flood the eye thoroughly with water for 15 minutes.
2. If the casualty is lying down, turn his head to the side. Hold the lids open and pour water from the inner corner outward. Remove any loose particles of dry chemicals floating on the eye by lifting them off gently with a sterile gauze or a clean handkerchief.
3. Do not irritate with soda solution.
4. Mobilise the eye by covering with a dry pad or protective clothing. Seek immediate medical aid.

10 POISONING, FIRST AID AND ANTIDOTES

Some substances when taken into the body in fairly large quantities or lethal doses can be dangerous to health or can cause death. Such substances are called poisons.

Poisons get into the body by swallowing or by breathing poisonous gases, or by injection through skin.

Poisoning by Swallowing (Mouth route):

Sometimes acids, alkalis, disinfectants etc., are swallowed by mistake. They burn the lips, tongue, throat, food passage and stomach and cause great pain. Other swallowed poisons cause vomiting, pain and later on diarrhoea. Poisonous fungi, berries,' metallic poisons and stale food belong to the later group. Some swallowed poisons affect the nervous system. To this group belong (a) alcoholic drink (methylated spirit, wine, whisky etc.) when taken in large quantities, and (b) tablets for sleeping, tranquillisers and pain killing drugs (Aspirin or Largectil). All these victims must be considered as seriously ill. The symptoms are either delirium or fits or coma (unconsciousness). Some poisons act on nervous system (belladonna, strychnine).

Poisoning by Gases (Nose route) :

Fumes or gases from charcoal, stoves, household gas, motor exhausts, chemicals and smoke from explosions etc.; cause choking (asphyxia) which may result in unconsciousness in addition to difficulty in breathing.

Poisoning by Injection (Skin route) :

Poisons get into the body through injection, bites of poisonous snakes and rabid dogs or stings by scorpions and insects. Danger to life is again by choking and coma.

10.1 General First Aid in Poisoning:

1. Poisoning is a serious matter. Patient must be removed to a hospital/or a doctor be sent for, at once with a note of the findings and, if possible, the name of the poison.

2. Preserve packets or bottles which you suspect contained the poison and also any vomits, sputum etc.,. for the doctor to deal with.

3. If poison is' not known :
   Make a quick assessment of the likely route of exposure by examining the eyes, mouth, nose and skin of the victim for signs of the chemical itself or damage it has caused such as swelling, redness, bleeding, burns, discharge of fluid or mucous or pallor. Drooling, difficulty in swallowing, a distended, painful, hard, or rigid abdomen all indicates possible ingestion of a corrosive or caustic substance. If respiration is rapid, shallow, noisy or laboured, suspect inhalation. If the face has been splashed with chemical, eye contact is likely.

4. Poisoning by inhalation:
   Remove victim from exposure while protecting yourself from exposure.
   If breathing has stopped, administer artificial respiration using a bag-valve mask. Do not use mouth to mouth resuscitation. Instead, use chest pressure-arm lift technique. Maintain an open airway.
   Arrange for transport of the victim to a medical facility.

5. Poisoning by Ingestion
   Do not induce vomiting if he has abdominal pain or burns in mouth. If no such problem, then induce vomiting by syrup of ipecac. Lastly give I or 2 cups of water to drink.

6. Poisoning by skin contact:
   Remove the victim from the contaminated area: Be careful to protect your lungs, skin and eyes while doing so. Remove the victim's clothing, shoes and jewelry from the affected areas, cutting them off if necessary. Do this under a shower or while flushing with water. Continue to flush with water until all traces of the chemical are gone and any feeling of soapiness has disappeared also. Rinse for at least 15 minutes cover the victim with a blanket or dry clothing. Inform and refer the victim immediately to .a physician for his advice.

   In case of inflammation, burns, blisters or pain-

   Loosely apply a dry sterile dressing if available or use a clean dry cloth for it. Inform and refer the victim immediately to a physician for his advice.

   If the victim is in a state of shock -

Lay him down on his side and cover him with a blanket. Elevate his feet. Inform and refer the victim immediately to a physician for his advice. Do not break open blisters or remove skin. If clothing is stuck to the skin after flushing with water, do not remove it.

Do not rub or apply pressure to the affected skin
Do not apply any oily substance to the affected skin.
Do not use hot water.

7. Poisoning by eye contact:
Remove the victim from the contaminated area. Be careful to protect your lungs, skin and eves while doing so. Act quickly. Flush the victim's eyes with clean tepid water for at least 15 minutes. Has the victim lie or sit down and tilt his head back Hold his eyelids open and pour water slowly over the eyeballs starting at the inner corners by the nose and letting the water run out of the corners.
The victim may be in great pain and want to keep his eyes closed or rub them but you must rinse the chemical out of the eyes in order to prevent possible damage.
Ask victim to look up, down and side to side as you rinse
Transport victim to the medical facility as soon as possible. Even if there is no pain and vision is good, a physician should examine the eyes since delayed damage may occur.

If eyes are painful,

1. Cover loosely with gauze or a clean, dry cloth.
2. Maintain verbal and physical contact with the victim.

8. **If unconscious -** (a) Do not induce vomiting (b) Make the casualty lie on his back on a hard, flat bed without any pillow and turn the head to one side. As there is no pressure on the stomach and the gullet is horizontal the vomited matter will not get into the voice box and the tongue will not close the air passage. This is also the best posture for giving artificial respiration, if needed (c) Sometimes when there is excess of vomiting the three-quarterprone posture (i.e. the casualty is made to lie on his side with one leg stretched, the other bent at knee and thigh) will make things easier for the casualty (d) If breathing is very slow or stopped, start artificial respiration and keep it up till the doctor comes, (e) Maintain open airways (f) Do not use mouth to mouth re$uscitation (g) Do not give any thing by mouth (h) In case of signs of shock, elevate-his feet, 20-30 cm and cover him with a blanket (i) Arrange for sending to medical facility.

9. **If conscious -** (a) Aid vomiting by tickling the back of throat or make him drink tepid water mixed with 2 tablespoons of common salt for a tumbler of water (b) Even if conscious, when the poison is a corrosive do not induce vomiting. Signs of corrosives: Lips, mouth and skin show grey white or yellow, patches which are to be looked for :acids, alkalis etc., cause such burns.

First Aid: Factories which use certain poisons shall have the respective antidotes ready and displayed in an easily available place. The personnel should be taught about the use of antidotes - so that anyone can render assistance in case of emergency. For antidotes see Part-10.6.

The poison must be diluted by giving large quantities of cold water (chilled, if possible) This will dilute the irritant and delay absorption and will replace fluid lost by vomiting. Tender coconut water will be even better as this will be a food and also a diuretic.

Soothing drinks should be given. Milk, egg beaten and mixed with water or sojee congee are good for the purpose.

10.2 Alcohol Poisoning :

Alcohol taken in considerable (toxic) quantities may cause fatal poisoning,. A fatal dose of ethyl alcohol is 8 g per I kg body weight. Alcohol affects the heart, blood vessels, gastro intestinal tract, liver, kidneys and mainly the brain. In a case of severe intoxication, sleep is followed by unconscious state. • Vomiting and involuntary urination are frequent symptoms. The respiratory centre is drastically inhibited, which is manifested by irregular breathing. Death ensues when the respiratory centre becomes paralysed.

First aid : Fresh air should be provided (a window open or the victim taken outside) and vomiting induced by 'minor lavageas'. If the patient is still conscious, he should be given hot strong coffee. A respiratory arrest is managed by artificial respiration.

10.3 Poisoning with Acids and Alkalis :

In poisoning with concentrated acids and alkalis, a grave condition rapidly develops, in the first place, to extensive burns in the mouth, throat, oesophagus, stomach and often the larynx. Later, the absorbed toxins affect the vital organs (e.g. liver, kidneys, lungs, or heart). Concentrated acids and alkalis are able to destroy .tissues. The mucous membranes, being less resistant than the skin, are destroyed and necrosis occurs more rapidly involving deeper layers.

Burns and scabs form on the mucous membrane of the mouth and lips. In a bum due to sulphuric acid, the scabs are black, in a burn due to nitric acid they are greyish-yellow, in one due to hydrochloric acid they are yellowish-green and in one due to acetic acid greyish-white.

Alkalis more easily penetrate the skin and affect deeper layers. The burnt surface is loose, decomposed and whitish in colour.

As soon as an acid or alkali is swallowed the patient feels strong pain in the mouth, behind the breast bone and in the epigastrium. When laid down he tosses in bed from unbearable pain. There is almost always tormenting vomiting often with admixtures of blood. Painful shock rapidly develops. The larynx may swell and asphyxia develops. When an acid or alkali is taken in great amount, cardiac weakness and collapse rapidly develop.

Poisoning with ammonium hydroxide takes a grave course. The pain syndromes is attended by asphyxia because the airways are also affected.

The person -who is rendering first aid must find out at once which chemical caused the poisoning because the treatment varies according to the type of poison.

If the poisoning was caused by concentrated acids and the symptoms of oesophageal or gastric perforation are absent, the stomach should be leveraged through a thick stomach tube using for it 610 litres of warm water mixed with magnesium oxide (20 g per litre of liquid) or lime water. Sodium carbonate is contraindicated for a gastric lavage. "Minor lavage " i.e. drinking 4-5 glasses of water and then inducing vomiting, will not alleviate the patient's condition and sometimes may even promote absorption of the poison.

If a stomach tube is unavailable, the patient may be given milk, oil, egg, white, mucilaginous decoctions, or smoothing substances. In poisoning with carbolic acid (Phenol, Lysol) milk, oil or fat should not be taken. Magnesium oxide mixed with water or lime water should be given in this case, as in poisoning by all other acids. Cold compresses or ice should be put on the epigastric region to lessen pain.

When the poisoning is due to concentrated alkalis, the stomach should be immediately lavaged with 6 10 litres of tepid water or a I per cent citric or acetic acid solution within four hours of the poisoning. When a stomach tube is unavailable and the patient's grave condition (swelling of the larynx) prevents a stomach lavage, mucilaginous solutions are given, 23 per cent citric or acetic acid solution (I tablespoonful every 5 minutes), or lemon juice. Rinsing of the mouth or administration of sodium hydrochloride solution is contraindicated.

The patient should be immediately admitted to a medical institution where he will be given the necessary urgent medical help.

It should be kept in mind that when a perforation of the oesophagus or stomach is suspected, they being manifested by severe pain in the stomach and unbearable pain behind the breast bone, drinking and moreover, lavage of the stomach are not permitted.

10.4 Poisoning with Toxic Chemicals :

The latent course of the disease is 15-60 minutes, after which the symptoms of the affection of the nervous system appear (e.g. enhanced salivation, discharge of sputum and perspiration). Breathing accelerates and becomes noisy, as rail heard at a distance. The patient becomes restless and excited. Cramp appears in the legs and the intestine undergoes increased peristalsis which is followed by muscular paralysis and paralysis of the respiratory muscles. The respiratory arrest that follows, causes asphyxia and death.

In accidents connected with the inhalation of the toxic chemicals the victim must be immediately hospitalised. If possible, he should be given 6-8 drops of a 0.1 per cent atropine solution or 1-2 tablets of belladonna. When respiration is arrested, artificial respiration should be carried out. When the poisoning is caused by toxins getting into the gastro-intestinal tract, the stomach should be washed with water mixed with suspension of activated carbon Saline purgatives should also be prescribed. The toxic substances should be removed from the skin and mucous membranes with running water.

10.5 Carbon Monoxide Poisoning :

Carbon monoxide poisoning may occur in the chemical industry where it is used for synthesizing certain organic compounds (acetone, methyl alcohol, phenol etc.), in poorly ventilated garages, in furnaces or in stuffy, freshly painted premises. It may also happen in households when the stove shutters are closed too early in premises with stove heating.

The early symptoms are headache, heaviness in the head, nausea, dizziness, noise in the ears and palpitation. Later muscular weakness and vomiting occur. If the victim remains in the poisonous atmosphere, the weakness intensifies, somnolence, clouding of consciousness and dyspnoea develop. The skin turns pale and sometimes bright red spots appear on the body. In further exposure to carbon monoxide the patient's respiration becomes shallow, convulsions develop and paralysis of the respiratory centre terminates in death.

First Aid : The victim must be immediately removed from the poisonous surrounding, better into the open air in warm weather. If his breathing is weak and shallow or arrested, artificial respiration should be continued until adequate natural breathing or the true signs of biological death appear. Rubbing should be carried out and hot water bottles applied to the legs. A brief whiff of ammonium hydroxide is beneficial A patient with severe carbon monoxide poisoning must be immediately hospitalised in order to prevent possible grave complications in the lungs and nervous system which may develop later.

For chemical safety see Chapter-18.

10.6 Antidotes for some common Chemicals :

Antidotes are therapeutic agents used to counteract the toxic effects of specific xenobiotics. These are heterogenous group of substances consisting of pharmaceuticals, biological agents and immunoglobulin fragments. Different mechanisms of action are involved Some specifically act at the receptor sites while others exert their effect by changing the metabolism of the poison counteracting the toxic injury or just forming the inert complex with the poison.

Antidotes acting at receptor sites: Drug intoxications are mostly treated with these antidotes. However, Atropine is a specific antidote for organophosphate or carbamate pesticide poisoning. Similarly physostigmine for Dhatura and neostigmine for Curare poisonings are useful. Others include, naloxone for opioid, flumazenil for benzodiazepines and physostigmine for atropine poisoning.

Antidotes changing the metabolism of the poison: These antidotes either interfere with the metabolism of the toxic agent thereby reducing the toxicity or strengthen the detoxifying capacity of the body. Antidotes included in this group are ethanol, 4-methyl pyrazole, acetylcysteine, sodium thiosulphate, folinic acid and pyridoxine.

Antidotes binding with the poison and forming less toxic complexes: In this category, poison may be adsorbed or chelated by the antidote. Activated charcoal effectively adsorbs a large variety of drugs and toxins, thereby decreasing their bioavailability and enhancing elimination. Role of multiple doses of activated charcoal as gastrointestinal dialyzer is being recognised in the treatment of poisoning, due to drugs. On the other hand, chelating agents like BAL, penicillamine and DMSA form complexes with heavy metals, thereby preventing or reversing the binding of metallic cations to body ligands.

Antidotes counteracting the toxic injury: The agents in this group reverse a chemically induced damage or functional disturbance and restore physiological conditions. Amyl nitrite, sodium nitrite, sodium thiosulphate, methylene blue, dantrolene, benzyl penicillin, glucagon, oximes, etc. are common examples.

In general, antidotes should be given in adequate doses as early as possible in cases of poisoning. Some antidotes cause serious adverse reactions. Hence, both the risk and the benefits of the antidotal therapy must, therefore, be carefully evaluated and the patient must be monitored regularly. At times the half-life of some antidotes like naloxone, atropine is much shorter than the toxin, in which cases the antidotal therapy must be continued till the symptoms of the poisoning subside.

Table 26.1 gives antidotes or medical treatment for some commonly used chemicals.

Table 26.1 : Antidotes or Medical Treatment for some commonly used Chemicals

Sr. No.	Chemical	Antidote / Medical Treatment
1	Acids and Sulphur Oxides (SOx), or Alkalis	▪ Wash with plenty of water if eyes or skin is affected.

		▪ Do not give chemical antidote because it increases heat and injury with reaction. Do not induce vomiting. ▪ Milk, lemon water or milk of magnesia can be given.
2	Acetonitryl, Acrylonitryl, Lactronitryl, Cyanogen chloride or bromide	▪ Very careful treatment of cobalt E.D.T.A. (calocynor) and if that is not effective give nitrite/thio sulphate treatment
3	Alkali phosphates and Ammonia	Immediately give water or milk and induce vomiting. For the hypocalcimic effect of phosphate give 5 ml intravenous injection of 10% calcium gluconate. If eye or skin is affected wash with plenty of water for 15 min.
4	Ammonia	If skin is affected then wash with plenty of water for 15 min. and then wash with dilute lactic acid and apply soframycin cream. If eye is affected then wash by eye fountain with plenty of water for 15 min. Put one drop of 0.4% Benzocaine (Novocaine) solution in eye. Boric or lactic acid solution eye drops can also be given, If entered in throat then give smell through cotton dipped in ethanol or ether through nose. Administer oxygen in case of breathing difficulty.
5	Aniline, Toludine and Nitrobenzene	Methylene- Blue (1% solution). Ascorbic acid (5% solution) Administer oxygen in case of breathing difficulty.
6	Anticoagulants (Heparin) etc.	Protamin sulphate (1% solution), Vitamin-K (1% solution).
7	Antimony and Stibine	Dymer caprol (BAL)
8	Arsenic	BAL (British Anti Lewistic compound) ie Dimer caprol, penicillamine. Induce vomiting.
9	Arsine (Hydrogen arsenide)	Mercaptide (40% solution, Dimercaptopropanol, penicillamine).
10	Atropine	Pilocarpine (1% solution). Proserin (0.05% solution).
11	Barium and its salt	Magnesium sulphate (30 gm in 250 ml water). Morphine (5 to 10 mg.)
12	Barbiturates	Barmegride (0.5 % solution).
13	Benzene, Toluene & Xylene	Skin is affected then wash with plenty of water. Administer Oxygen or shift to fresh air. Diazepam 0.1 mg / kg. (iv), bed rest.
14	Beryllium	Calcium edentate, Prednisolone.
15	Bis-chloro methyl ether	N-acetyl-L-cysteine.
16	Bleaching solution	Milk, melted ice-cream, eggs, milk of magnesia, aluminium hydroxide gel. Do not give acid antidotes.
17	Bromides	Skin is affected then wash with plenty of water. Give 1 gm. Salt in water by mouth. If this is not possible then intravenous (iv) injection of normal saline. Give milk and water.
18	Boric acid and Boron derivatives	Ipecac solution and activated charcoal. Infra muscular (im) injection of 5% dextrose if nausea.

19	Cadmium	Calcium disodium edetate i.e. CaNa2EDTA by intravenous or muscle.
20	Carbon monoxide	Administer Oxygen (100% pure), intravenous injection of 1 gm/kg of 20%mannitol, or 1 mg./ kg of Prednisolone.
21	Carbon tetrachloride or Chloroform	N-acetyl-L-cysteine.
22	Carbonyls	Tablets of Sodium diethyl dithio carbamate, 2 tablets immediately and then 1 tablet every two days for next two days. Administer Oxygen in case of breathing difficulty.
23	Cardiac Glycosides	Potassium chloride (0.5% solution). Atropine sulphate (0.1% solution), Tefacin calcium (10% solution).
24	Chlorine, Bromine, Phosgene	Skin is affected then wash with plenty of water. Apply Sodium bicarbonate and again wash with water. Eye is affected then flush eye in eye fountain. Put 2-3 drops in eye of Pontocaine 0.5% solution ot Benzocaine (Novocain) 0.4% solution. If inhaled then give smell through ethanol or ether dipped cotton. ; Give milk, buttermilk or lemon water. Give 02 in case of breathing difficulty
25	Chlorates	Ipecac solution, activated charcoal, milk. Don't give Methylene blue. Add 2 to 5 gms. Sodium thiosulphate in 200 ml of 5% Sodium bicarbonate solution and give by mouth.
26	Cosmetics (Bromates)	Intravenous injection of 1 ml./kg Sodium thiosulphate (10% solution)
27	Chromium	Dimercaprol. .Give high vitamins, protein and carbohydrates in food. Methylene blue.
28	Cyanides and Thiocyanate insecticides	Methylene blue or Calocyanides injection. If inhaled gives smell of amyl nitrate ampule (0.2 ml) every 5 minutes. Intravenous injection of Sodium nitrite (3% solution) and Sodium thiosulphate (25% solution) but if blood pressure decreases, then stop it. 4 DMAP (Dimethyl amino phenol) 3 mg/kg, iv, along with thiosulphate. Hydroxocobalamine, 4 gm,iv, in 5% dextrose. Dicobalt edetate, 300 - 600 mp-, iv, over l-5min.
29	DDT (Halogenated insecticides)	Ipecac syrup, activated charcoal. Saline cathartic, Diazepam (10 mg.) by intravenous injection, wash skin with soap and water. In case of breathing difficulty administer Oxygen
30.	Dichlorophenoxy acetic acid insecticides	Ipecac syrup, activated charcoal. Saline cathartic, Lidocane (50-100 mg by intravenous injection)..
31.	Dimethyl sulphate	Skin is affected then apply Magnesium oxide paste and give injection of Corticosteroid.

		In case of breathing difficulty administer Oxygen.
32.	Dichloro methane	Hydro cortisone (200 mg every 4 hours). In case of aspiration pneumonia give antibiotics.
33.	Dinitrophenol or Cresols	5% Glucose saline by intravenous injection.
34.	Ethanol	2 gm. Of Sodium bicarbonate in 250 ml water, Diazepam 10 mg., by intravenous. Skin or eye is affected then wash with plenty of water.
35.	Ethylene or Diethylene glycol	Ethanol, Calcium gluconate Pyridoxine
36.	Fluorine, Hydrogen fluoride and derivatives.	Intravenous injection of 10 ml. Calcium gluconate (10% solution). If serum magnesium level is low then give 10 ml Milk of magnesia every hour. Give more milk and liquids. If eye is affected then wash with plenty of water.
37.	Formaldehyde	Milk, activated charcoal or water.
38.	Formalin	Ammonium chloride or Ammonium carbonate (3% solution).
39.	Hydrogen sulphide, other sulphides and Mercaptans	Shift in fresh air or administer Oxygen. Give inhalation of ethanol or ether drops. Amyl nitrite or Sodium nitrite, Pyridoxine 20 mg./kg. or 10% urea 1 gm./kg by intravenous injection.
40.	Hydrogen cyanide	Give inhalation of 0.2 ml amyl nitrite dipped cotton. Sodium nitrite (1% solution). Sodium thiosulphate (30% solution), Cromosmon (1% methylene blue in 25 % glucose solution).
41.	Iodine and compositions	Milk, Fine starch solution, 100 ml of 1% Sodium gluconate 10% solution.
42.	Iron salts	Careful treatment of deferroxamine therapy.
43.	Lead compounds	$CaNa_2EDTA$, D-Penicilliamine (oral), BAL (with CaEDTA), Induce vomiting, then give Magnesium sulphate in water.
44.	Magnesium salts	Intravenous injection of 1 ml/ kg of Calcium gluconate 10% solution.
45.	Manganese	Calcium edentate
46.	Mercury as Hg, Alkyl or Aryl compounds	Give white of egg in water. Later give milk, Then induce vomiting. BAL, D-Pencilliamine, n-Acetylcysteine, Dimercaptopropane- 1 sulfonate DMPS).
47.	Metals (Heavy metals, mercury, lead, copper, cobalt, arsenic, nickel)	Unithol (BAL, dimercaprol, 5% solution), Tetacin calcium (10% solution), Penicillamine Dextrose (10%) by intravenous injection. Chillating agent for effect of mercury.
48.	Metal Compounds (Heavy metals compositions)	Activated carbon (carbolin) BAL
49.	Methanol	Ethanol (30% solution from inside, 5% solution from outside i.e. by intravenous injection), Epicake Syrup. In case of acidosis give Sodium bicarbonate. In case of delirium give Diazepam 10 mg. by intravenous injection. Folinic acid (Leucovorin), 1 mg/kg, iv, 4 hourly.

50.	Metaldehyde	D-Penicillamine, Ascorbic acid or Thiamine to be given carefully.
51.	Naphthalene	5 gm. Sodium bicarbonate every 4 hrs. and keep urine alkaline. Give 1 ml/kg, furosemide in liquid. Blood transfusion till haemoglobin becomes normal -60 to 80%.
52	Nitrates, Nitrites, Nitrobennzene Sulfonamides Dapsone	Methylene blue, 1-2 mg / kg, iv, over 5 min.
53	Nitrogen oxides (NOx)	Prednison or prednisolone 5 mg. every 6 hrs. interval.
54	Orgnaic phosphate or carbamate insecticides (abet, dizionon, dimate, EPN, Ethyl Phosphamidon, Phosvel, Selithion, Aldecarb, Baygon, Sevin etc.)	Ipecac syrup, Atropine sulphate 2 mg. by intravenous injection every 3-8 mins interval. Prelidoxim by intravenous. Obidoxim (Toxogonin), skin to be washed with soap and water.
55	Orgao phosphorous insecticides (e.g. Malathion, Parathion, Monocrotophos, Phorate)	Atropine injection, atropine sulphate (0.1% solution), Nalorphine hydrochloride (0.5% solution), Trimedoxim bromide (15% solution), Pyridine Aldoxy Methyodate, Diperoxim, Biodexim and Isonitrocin (40% solution), Pralidoxim, RAM, TOXOGONIN.
56	Oxalic acid	Milk, lemon water, chalk or calcium lactate, calcium chloride or calcium gluconate with liquid. 10% calcium gluconate or chloride 10 ml. by intravenous injection.
57	p-Nitro Chlorobenzene (PNCB)	Methylene blue
58.	Phenol & Derivatives	Shift in fresh air, activated charcoal and 240 ml. milk. If skin or eye is affected then wash with plenty of water for 15 min. If skin is affected then wash with Polyethylene glycol(PEG).
59.	Phosgene	Cortisone acetate 1 mg./kg by mouth - thrice a day. In case of breathing difficulty administer Oxygen
60.	Phosphorous, Phosphine & Phosphides	10 ml. Calcium gluconate (10%) by intravenous injection, 5% glucose in water. Travert (10% invert sugar) by intravenous injection.
61.	Potassium permanganate	Hot milk, Methylene blue (1% solution) Ascorbic acid (5% solution)
62.	Silica & Asbestos dust	Reduce dust level by local exhaust ventilation. Use airline respirator.
63.	Silver nitrate & other salts	10% Salt (Sodium chloride) solution, milk and for reducing, pain Demrol or Codeine.
64.	Tobacco & Nicotine	Induce vomiting, Atropine (large dose). In case of difficulty in breathing, administer Oxygen.
65.	Vinyl chloride	Skin is affected, wash with plenty of water. Eye is affected then keep eye open and allow material to vaporise. Don't apply any eye drops In case of breathing difficulty, administer Oxygen. If injected then induce vomiting. Give one spoon mineral oil and after that give sodium/magnesium sulphate (one spoon) in a glass of water. Give strong tea or coffee if feeling exhausted.

66.	Zinf fumes and metal fume fever	Prednisolone, Aspirin, Bed rest.

E X E R C I S E

1 Explain, State, Discuss or Mention

1. General rules or principles of first-aid.
2. Priority steps of first-aid treatment
3. First-aid treatment method for
   (a) Shock (b) Suffocation (c) Heat stroke (d) Bleeding Nose or Ear (e) Heart attack (f) Dog bite OR Snake bite (g) Coma.
4. First aid treatment for different types of wounds.
5. The first-aid treatment for
   (a) Minor injuries (b) Bruises and contusions (c) Sprains of ligaments (d) Spine Fracture.
6. Types of fractures and first - aid treatment for them.
7. In what body parts a foreign body can enter and what should be their respective firstaid treatments?
8. Causes of electrical injuries and first aid for them.
9. Types and methods of Artificial Respiration.
10. Causes of Burns and Scalds.
11. How to help a person whose clothes have caught fire?
12. How to help rescuing persons from fire?
13. First aid of serious burns and scalds.
14. General first aid for poisoning.
15. First aid treatment when poison is not known.
16. First aid treatment for Alcohol poisoning.
17. First aid treatment for poisoning with Acids and alkalis.
18. First aid treatment for poisoning with toxic chemicals.
19. First aid treatment for CO poisoning.
20. Meaning and types of Antidotes.

2. Write Short Notes on -

1. Need of the First - aid.
2. Meaning of First-aid.
3. Dr. ABC and Head-foot examination.
4. Ten Commandments of first-aid.
5. First aid for foreign body in the Eye OR in the Ear.
6. Types of Dressing OR Bandages.
7. Mouth to mouth breathing.
8. External Heart Compression.
9. First aid for minor burns and scalds.
10. First aid for chemical burns.
11. Meaning and types of poisoning.
12. Treatment for poisoning by skin contact OR Eye contact.
13. Antidote treatment for Ammonia OR Chlorine effect.
14. Antidote treatment for Cyanides OR DDT.
15. Antidote treatment for Organo phosphorus OR Tobacco.

3. Explain the difference between with respect to

1. First-aider and Doctor

2. Burn and Chemical burn
3. Shock and Electric shock.
4. Suffocation and Infection.
5. Dog bite and Snake bite.
6. Open injuries and Closed injuries.
7. Foreign body in the Nose and that in the Throat.
8. Dressing and Bandage.
9. Mouth to Mouth breathing and Mouth to Mouth and Nose breathing.
10. Mouth to Mouth breathing and CPR.
11. Burns and Scalds.
12. Chemical burn and Nuclear burn.
13. Degrees of burn and Percentage of burn.
14. Treatment for Acid burns and that for Alkali burns.
15. Treatment for poisoning by Inhalation and that for Ingestion.
16. Treatment for poisoning when a victim is conscious and when he is unconscious.

4. Comment on following explaining whether it is true or false?

1. First aid cannot prevent accident but it can prevent further injury.
2. First aider has to play a role of a doctor.
3. Fracture may be an open or closed injury.
4. Atropine is a specific antidote for carbamate pecticide poisoning.
5. Activated charcoal is an antidote for gastrointestinal poisoning.
6. BAL, as chelating agent is a useful antidote for poisoning due to heavy metals.
7. There is no medical antidote for lung damage due to silica or asbestos dust.
8. Antidote therapy should be continued till the symptoms of poisoning subside.
9. Half-life of some antidotes (e.g. Atropine) is much shorter than the toxin.
10. Sodium thiosulphate is an antidote which changes the metabolism of the poison or strengthens the detoxifying capacity of the body.

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CHAPTER – 27

Factories Act and Case Law

THEME

1 HISTORY OF THE SAFETY MOVEMENT AND THE FACTORIES ACT

1.1 Development of the Safety Movement:

1.1.1 The Oldest History of Labour Laws :

Age old concept of safety in India and abroad, with brief history , has been discussed in Part 5 of chapter-I, and Part I of chapter-7. This shows that in ancient India, the class of labourers, artisans and artists was duly respected by the society and the problems of their livelihood, health and safety were also considered as mentioned in old literature and in Kautilya's Arthshashtra(BC 2000).

Legal history dates back to 14th century in England. It is mentioned that the initial enactments by the English Parliament were in the interest of employers and not in the interest of employees. The statute of Labourers of 1349 and 1350 made labour compulsory, confined labourers to their existing places of residence and fixed maximum rates of wages. Some of these restrictions were later on relaxed and others extended by the Apprenticeship Act of 1562. This statute was not finally repeated until 1875.

Due to the change in political power and industrial development in England as well as in USA, laws were passed in the interest of workers from 19th century. Much of this legislation was aimed to promote safety and health of the workers.

As early as 1898, the US supreme court upheld a Utah Statute prohibiting women employment in mines for more than 8 hours a day.

Initially the need of legislation was justified by the courts for children and women and not for adult men. Following old citations clarify this

1. Labour legislation may be enacted which applies to children and not to adults. Regulation of hours of labour may be made for women and not for men'[Muller v/s Oregon, 208 US 412 (1908)].
2. Regulation of hours of labour may be made to apply to especially unhealthful occupations and not to others' [Holden v/s Hardy, 169 US 366 (1898)].

An Oregeon statute of 1903 limited to 10 hours a day the labour of women in factories, laundries and mechanical establishments. The US court upheld this law in 1908, constitutional justifying the injurious effects of long hours of labour upon the health of women. In 1915, the same court also upheld the more drastic California statute limiting the labour of women in certain industries to 8 hours a day and 48 hours a week as a reasonable exercise of law [Miller v/s. Wilson, 236 US 373 (1915)]

Child labour laws were adopted and justified in almost all countries. The state was considered to be a guardian and its parental rights were upheld by the courts to fix the age-limit below which children shall not be employed, to regulate their working hours and to prohibit their employment in dangerous occupation.

1.1.2 History of Labour Legislation in England:

The common law foundation of labour laws in England was described in the words protection and improvement. Three reasons were given for such justification :

1. To protect exploitation of defenceless workers by avaricious employers.
2. Looking to the complexity of industrial organisations and operations, without compulsion of law, it was not possible to safeguard the physical, mental and economic interests of the workers.
3. Protection and improvement of standards of employment were necessary also for social welfare and progress.

In 18th century the development of labour legislation in England was speeded, with the development of more and more industries. The agitation of Robert Peel and Robert Owen resulted in the Health and Morals Act to regulate the labour of bound children in cotton factories in 1802. Children were protected by the second of the Factory Acts enacted in 1819. In 1883 all textile mills were brought under regulation and provisions were made for-

1. Prohibition of child employment under 9 years of age and also during night hours.
2. Children between 9 to 13 years, might work for 8 hours a day.
3. Young persons between 13 to 18 years, might work for 12 hours.
4. Holidays.
5. Certificate of fitness
6. Factory Inspectors for enforcement of the Act.
7. The Children's Half-time Act of 1844 provided for -
    1. Safe guarding of machinery.
    2. Accident reports.
    3. Public prosecution.
    4. Damages(Compensation) for accidents.
    5. Employment of children for half-time only, the other half to be spent in school.

6. Young persons including women, of age 13 to 18, to work for 12 hours a day and not during night.

The Ten-Hour Act, 1847 secured the 10 hour day for women and young persons.

But all these measures failed to reach the thousands of women and children who were working in mines. The Mines and Collieries Act of 1842 was enacted to prohibit the employment of women and children under 10 years of age in underground mines.

The Factory Acts were extended to all large industries in 1864 and to smaller workshops in 1867. In 1878 the Factory and Workshop Consolidation Act repealed all former laws and substituted a Factory Code which made regulations more stringent. The new Factory Code of 1902 raised the minimum age for child workers from II to 12 years.

For workers' social welfare, enactments were passed in England regarding Workmen's compensation, contract labour, sickness insurance, unemployment insurance, old age pensions, etc.

The law relating to factories in England is to be found not only in the Factories Acts of 1937, 1948 and 1961 but also in several orders and regulations issued by the Ministry of Labour.

The Boiler Explosions Act of 1882 and 189C provided for inquiry in an accident of boiler explosion.

1.1.3 Stages of Development of Safety Movement:

As per the Encyclopaedia of Sciences (Macmillar Co.) the safety movement developed in five stages :

1. The improvement of the environment or the removal of physical hazards.
2. The improvement of personal practices through a combination of education and supervision.
3. The management's direct involvement at a lower level in safety problems. This leads to the setting up of various departments specifically charged with responsibility of ensuring the safety, health and the efficiency of the workers such as Personnel, Medical, Safety, Industrial Hygiene and Training.
4. With the growing complexity of industry and the recognition that safety is an essential element in the profitability and the effective functioning of the enterprise, safety was accorded front rank status. It was accepted that safety cannot be viewed in isolation, but has to be considered as an essential element in an integrated approach to the planning, organisation and operation of an industrial enterprise and not something to be super-imposed of an existing organisation. Safety should be considered from the design stage and extended to the product safety and total loss control.
5. It is in fact a co-operative effort on the part of industries to prepare codes and standards to pool and disseminate information of technical aspects relating to safety.

1.1.4 History of Factory Legislation in India :

The first time the public attention was drawn towards a report in 1873, 'Administration of the Bombay Cotton Department wherein the writer Major Moore described the factory conditions in Bombay with reference to long working hours, conditions of women and children of six years working from sunrise to sunset with a small interval of half an hour and only two holidays in a month.

Based on this report the Secretary of State wrote to the Bombay Government in 1875 to appoint a Commission to determine whether legislation was necessary in that subject. As a result the Commission was appointed by a majority of seven against two not in favour of legislation.

About this time Miss Carpenter of Bristol, founder of the National Indian Association, had visite'd India and made inquiries about the Indian factory conditions.

Exploitation of child labour and the unrestricted employment of women were among the worst features of earlier factories in India. Maj. Moore, Mr. Ballard and Mr. Alexander Redgrave were' some of the earliest to urge the necessity for factory legislation in India on the lines of the British Factories Act to check these evils. Almost simultaneously, the Lancashire Cotton interests, apprehensive at the phenomena growth of the Indian Cotton Industry, also started an agitation for achieving the same object, their aim being directed towards neutralising the advantages the Indian capitalists had with regard to cheap labour. Such extraneous considerations resulted in the merits of legislation being obscured and a counter agitation was therefore, started by the Indian capitalists against any form of legislative enactment. A commission set up in 1875 by the Bombay Government at the instance of the Secretary of State recommended prohibition of employment of children under 8 years and a 12 hours day for adults.

1.2 The Factories Act, 1881 :

Some leaders like S.S. Bengalee fought for the labour's cause and were mainly responsible for getting a bill referred to the Indian Legislature in 1879. An organised body of workers also put in a strong plea before the legislature for redress of their grievances. Finally, the first Indian Factories Act, 1881 (15th of 1881) was enacted. The most important provisions therein were:

1. Prohibition of employment of children under 7 years and their double employment on the same day.
2. Working day of 9 hours for children.
3. Four holidays in a month for children.
4. Intervals of rest.
5. Fencing of dangerous parts of machinery.
6. Reporting of accidents.
7. The Act was made applicable to a factory with mechanical power and workers 100 or more.
8. District Officers, were expected to enforce the Act without any addition to their staff.

The clauses related to the work of women and holidays for them were dropped owing to 'the strong criticism by the employers.

The Act, though inadequate from almost all points to the abuses, nevertheless was significant in that it secured recognition of the principle that Government would interfere in the industrial relations to protect the weak and oppressed.

1.3 The Factories Act 1891 :

The inadequacy of the 1881 Act led to continued agitation by workers, under the leadership of Bengalee for its amendment. Meade King in 1882, after investigating labour conditions on behalf of the Bombay Government, made recommendations for amending it. Later on a commission sat in 1884 and considered the question in detail. During the sitting of the commission, the labour movement was increased, the workers met in a conference and .placed their view points before the Commission. Bengalee and Lokhanday took a prominent part in the Conference.

The agitation for protecting labour gathered momentum following the publication in 1886-S7 in England of the report of Mr. Jones who had studied the factory conditions in Bombay during the period 1883-86. In 1890, a Factory Labour Commission was appointed by the Indian Government to again review the position and make suitable recommendations. Finally, the Indian Factories Act, 1891 (No. II of 1891) was passed and came into force from 1-1-1892. Its main provisions were:

1. Registration of a factory on employment of 50 or more workers.
2. Local Government authorised to notify concerns employing even 20 workers
3. Non employment of children under 9 years.
4. Seven hour day for children between 9 & 14 years.
5. Eleven hour day for women with 1.5 hour interval.
6. Restrictions on employment of women and children during 8 p.m. to 8 am.
7. Weekly holidays for all workers.
8. Rest interval of 0.5 hour.
9. Provincial Governments authorised to make rules regarding sanitation and comfort.

1.4 The Factories Act 1911 :

The introduction of electric lights in the factories in 1895 and the devastating effects of plague at about the same time had its repercussions on the availability of labour to meet the increasing capacity for production. Evasions of the Act were widespread. Besides, the ginning factories which were the worst offenders had not been brought within the purview of the 1891 Act, as factories not working for more than 4 months in a year had been excluded.

The safety provisions in the 1891 Act also proved inadequate. This was brought to light by a number of tragic fires in the cotton presses between 1901 and 1905, resulting in over 50 deaths. The government of India took a serious view and introduced in 1905 a Bill for further amending the earlier Act and this was circulated for public opinion.

At the direction of the Secretary of State, the India Government appointed in 1906 a Textile Factories Labour Committee with Frier Smith as Chairman and again in 1907 the second Factory Labour Commission with Hon. Morrison as Chairman to investigate factory working conditions. A bill embodying the recommendations of these bodies was introduced and enacted the Factories Act 1911 (12 of 1911). It came into force from 1-7-1912. Its chief provisions were:

1. Limiting the hours of work of male adults and children to 12 and 6 respectively.
2. Children were required to produce certificates as to 'age and physical fitness.
3. Appointment of full-time inspectors for the enforcement of the Act and inspection and certification of factories.
4. Provisions for health and safety of workers.
5. Seasonal factories were included.
6. Power of local government for exemptions.
7. Prevention and punishment for breaches.

1.5 The Factories Act 1922 :

The inauguration of the ILO in 1919 after the First World War (1914-1918) lead to adoption of Conventions on working hours, minimum age, night work of women and young persons etc. The growth of the labour movement and the stirring of public interest on labour questions in India as aresult of a number of strikes led to the ratification in 1921 of most of the ILO Conventions. A 60 hour week conceded and night work for women and children under 14 was prohibited. In 1922 the Factories Act was amended to include within its scope :

1. Industrial undertakings using mechanical power and employing 20 or more persons.
2. The minimum and maximum age of children were raised to 12 and 15.
3. A six hours working day for children, a half hour rest interval after 4 hours work and prohibition of employment of a child in two factories on the same day.
4. Working hours II per day and 60 per week.
5. Control of artificial humidification.
6. No woman and children employment between 7 p.m. and 5-30 am.
7. Compulsory rest intervals and weekly holidays.
8. Measures for health and safety of .operatives.
9. Power of Government to notify factories employing workers more than
10. Laying down principles to grant exemption.

Minor amendments for administrative purpose were made in 1923, 1926 and 1931. By these amendments penalty was inflicted on parents or guardians for permitting their children to work m two factories on the same day and the Governments were given power to make rules for providing precautions against fire inside factories. General provisions remained the same till the major amendment in 1934.

1.6 The Factories Act 1934 :

Following serious labour unrest in the country, a Royal Commission was set up in 1929 with Mr. John Henry Whitley as President, to review existing law in detail and make suitable recommendations after conducting an enquiry into the labour's living conditions. This resulted in the Act of 1934 (25 of 1934) which came in to force from 1-1-1935. Its main provisions were:

1. Adequate inspection and strict observance of the Act.
2. Applicable to factories employing 20 or more workers and using power.
3. Provisions for seasonal factories working for 180 days or less.
4. Working hours 10 per day and 54 per week for all adults in perennial factories, 10 hours a day and 56 hours a week for continuous work and II hours a day and 60 hours a week for seasonal factories.
5. Daily hours for children (between ages 12 & 15) reduced to 5.
6. New category of adolescent (between the age 15 to 17) included.
7. Certificate of fitness from certifying surgeon for children and adolescents.
8. Spread over of 13 hours for adults and 7.5 hours for children.
9. No women or children employment between 7 p.m. and 6 am.
10. Overtime wages at the rate of 1.25 times the ordinary rate for work exceeding 60 hours a week.
11. A weekly holiday on Sunday and no consecutive work for more than 10 days without a holiday.
12. Provisions for health and safety amplified. Provisions for cleanliness, ventilation, lighting, no overcrowding, drinking water, sanitary facility, washing facility, fencing for dangerous machinery, rest room for more than 150 workers, creche for more than 50 women for their children below 6 years and first aid box were made.
13. Penalty up to Rs. 500 and enhanced penalty for repeated breach were provided.

1.7 The Factories Act 1948 (The present Act) :

The above Act was subsequently amended in 1935, 1936, 1937, 1940, 1941, 1944, 1945, 1946 and 1947 before it's major amendment in 1948.

During the Interim Congress Regime, a five year plan was drawn up to ameliorate the labour conditions in India and also to revise the Factories Act of 1934 on the line of the UK Factories Act 1937 and latest ILO conventions in the matters of safety, health, welfare, working hours, industrial hygiene, medical examination of young persons and submission of plans of factory buildings.

The 1942 Conference was important as being the first attempt at collaboration between Government, employers and workers in matters pertaining to Labour. Arising therefrom, a Plenary Tripartite Conference and a Standing Labour Committee had been set up to advise Government on Labour matters and this resulted in smoothening the way for introduction of legislative measures including the draft Bill.

The Factories Bill was introduced in the Constituent Assembly on 30-1-1948 passed by it on 28-8-1948, received the assent of the Governor General of India on 23-9-1948 and came into force from 1-41949.

Statement of Objects and Reasons :

It was stated in this part that the Factories Act 1934 revealed a number of defects and weaknesses and the provisions for safety, health and welfare were found inadequate and unsatisfactory. The large mass of workers was not covered by the Act and in view of the large and growing industrial activities in the country, radical overhauling of the Factories law was essentially called for and cannot be delayed.

It was also mentioned that "the present Act (of 1934) leaves important and complex points to the discretion of Inspectors placing heavy responsibility on them. In view of the specialised and hazardous nature of the processes employed in the factories, it is too much to expect Inspectors to possess an expert knowledge of all these matters. The detailed provisions contained in the Bill will go a long way in lightening their burden".

The Labour Minister explained in the Legislature on 30-1-1948 an admirable summary of the New Law and pointed out the broad changes that were brought about.

The Act at a glance :.

The main provisions of the Factories Act (63 of 1948) as it was standing before its major amendment in 1976, were as under :

It was containing II chapters, 120 sections and only one Schedule of List of Notifiable Diseases. Chapter wise subjects were as under :

1. Definitions of adult, adolescent, child, young person, machinery, manufacturing process, worker, factory, occupier etc.' and requirement of plans, licence and registration of a factory (workers' 10 with power and workers > 20 without power).
2. Appointment and powers of Inspectors and Certifying Surgeons.
3. Health provisions regarding cleanliness, waste disposal, ventilation and temperature, dust & fume, artificial humidification, overcrowding, lighting, drinking water, latrines &: urinals and spittoons.
4. Safety requirements of machine guarding, lifting machines, pressure plants, floors, stairs, pits, sumps, excessive weights, protection of eyes and precautions against dangerous fumes, explosive gas, dust etc., fire, building and machinery.
5. Welfare facilities of washing, clothing, sitting, first-aid, canteen, rest-room, crecheand welfare officer.

6. Working hours - 8 hrs a day, 48 hrs a week, spread over 10.5 hrs, rest interval 0.5 hr, weekly and compensatory holiday, double wages for overtime, notice of working hours, prohibition of double employment and overlapping shifts, muster roll, restrictions on women employment and exempting rules and orders.
7. Employment of young persons (15th to 18th year), child upto 14th year not allowed, certificate of fitness, medical examination, reduced working hours, muster roll etc.
8. Annual leave with wages, I day for every 20 work days, eligibility etc.
9. Special provisions to notify factories, dangerous operation, notice of accidents and diseases, power to take samples etc.
10. Penalties & procedure (maximum fine Rs. 500, enhanced Rs. 1000).
11. Supplemental i.e. appeals, returns, obligations of workers, rule making powers etc.

1.8 The Factories (Amendment) Act 1954:

The Government of India ratified the ILO Conventions No. 89 & 90 prohibiting employment of women and young persons during night in factories. Therefore sections 66, 70 and 71 of the Factories Act 1948 were to be amended. Simultaneously opportunity was taken to amend other provisions also. Therefore the Factories (Amendment) Act, 1954 (25th of 1954) came into force with following major amendments :

1. Type composing for printing was included in the definition of manufacturing process.
2. Amendment of Section 4.
3. Prohibition of women and young persons from cleaning, lubricating and machinery inmotion.
4. Encasement of machines.
5. Amendment of section 29 to prescribe clearly the safety requirements of lifting machines.
6. Allowing to work 6 hours at a stretch without any interval when the shift is of 6 hours.
7. Exempting overtime work in case a shift worker does not turn up in time.
8. Amendment of sections 66, 70 & 71 in conformity with the ILO Convention No. 89 & 90 prohibiting employment of women and Chilean during night in factories.
9. Revision of Chapter-VIII relating to leave with wages to fix 240 days attendance, to raise the limit of carried forward leaves etc.
10. Recasting of section 93 to clarify the responsibility of the owner and occupier. Few minor changes were also incorporated.

1.9 The Factories (Amendment) Act 1976:

After 1948 and 1954, industrial growth was continued and need of Safety Officer was felt to advise management in the matters of industrial safety and health. Due to so many judgements on the definition of 'worker' and tendency to not include 'contract labour' therein in want of proof of 'Master Servant relationship' and feeling need of changes in many other sections including penal section, the Factories (Amendment) Act 1976 (94 of 1976) was enacted and brought into force from 26-10—1976.

Its main amendments were :

1. Changes in the definitions of manufacturing process, worker, factory and occupier. Contract labour was included in 'worker'.

2. Approval of the plan and prior permission for the site.

3. Alterations in the provisions 'for inspector, certifying surgeons, cleanliness, disposal of waste and effluents, fencing of machinery, work on or near machinery in motion, striking gear and

devices for cutting off power, pressure plant, floors, stairs and means of access, precautions against dangerous fumes, precautions in case of fire, specifications of defective parts, safety of building and machinery, first aid appliances, creches, spread over, overtime wages, register of child workers, leave with wages, dangerous operation, notice of accidents, penalty for offences, determination of occupier in certain cases, limitation of prosecutions etc.

In above alterations the posts of Additional, Joint and Deputy Chief Inspectors of Factories were added, more conditions for cleanliness, fire escape, first-aid etc. were imposed, women strength for creche was reduced to 30, time limit of rules u/s 64 was extended to 5 years, more particulars of attendance in register and no permission to work without that was required by sections 62 (I-A) and 73 (I-A), carry forwarding of 'refused leave with wages', training and research institutes were included in section 86 for exemption purpose, the words 'manufacturing process or operation' were substituted in section 87 and requiring more welfare facilities including protective equipment and clothing under that section, time limit of one month for inquiry into fatal accident was fixed u/s 88(2), fine limit raised to Rs. 2000 from Rs. 500 u/s 92, and for enhanced penalty to Rs. 5000 from Rs. 1000 u/s 94 and provision of minimum fine in case of fatal accident and serious bodily injury (Rs. 1000 for death and Rs. 500 for serious bodily injury, these figures were doubled in case of enhanced penalty) was also made.

4. New additions were made by section 36A regarding use of portable electric light, section 40A for maintenance of building, 40B for Safety Officers, 62(1-A) and 73(1-A) for more particulars in muster roll, 88A for notice of dangerous occurrences and section 91A for safety and health surveys.

In new section 40-A power to give order to carry out measures suggested by Inspector for maintenance of buildings was given and u/s 40B Safety Officers were required for factories employing workers 1000 or more, and the State Government was empowered to notify factories for this requirement and to prescribe rules for the duties, qualifications and conditions of service of Safety Officers. These rules were prescribed in 1983. For these S. 0. Rules, 1983 see Part 8.1 of Chapter-6.

1.10 The Factories (Amendment) Act 1987:

The Bhopal accident created world-wide safety awareness and moved the governments to provide more stringent requirements for health and safety of workers and public. Therefore the Central and State Governments made necessary amendments in their Acts and Rules. A new Act 'the Environment (Protection) Act 1986' was enacted and the Factories (Amendment) Act 1987 was also enacted on 23-5-1987 providing a new chapter IV A on hazardous processes, many other requirements and severe penalties and imprisonment for breaches.

In its Statement of Objects and Reasons it was stated that -

"There has been substantial modernisation and innovation in the industrial field. Several chemical industries have come up which deal with hazardous and toxic substances. This has brought problems of industrial safety and occupational health hazards. It is therefore, necessary to amend the Act to provide specially for the safeguards against use and handling of hazardous substances and laying down emergency standards and measures. The amendments also include procedures for sitting of hazardous industries for the safety of general public. Provision has been made for workers' participation in safety management, and making the punishment stricter."

The Factories (Amendment) Bill, 1986 (Bill No. 141 of 1986) was introduced in Lok Sabha on 2-121986 and received the assent of the President on 235-1987 as the Factories (Amendment) Act 1987 (No. 20 of 1987), and published in the Gazette of India on 25-5-1987. By the Notification dated 29-10-

1987, Ministry of Labour, Govt. of India, the Act came into force from 1-12-1987 except sections 7B, 41F and the 2nd Schedule which came into force from 1-6-1988.

Its major provisions are :

1. Amendment of Section 2 adding the definitions of competent person, hazardous process and also clarifying the occupier for a firm, a company and government factories.
2. Insertions of section 7A and 7B for general duties of the occupier, manufacturers etc., section 87A giving power to prohibit employment on account of serious hazard, section 96A for penalty for breaches of section 41B, 41C and 41H, section 104A for proving limits of what is practicable etc., section 106A for jurisdiction of acourt, section IIIA for right of workers, section II 8A for restriction on disclosure of information and insertion of new Schedules I & II for the list of hazardous industries and permissible levels of certain chemicals.
3. Insertion of a new Chapter IV-A regarding hazardous processes adding section 41 A for constitution of Site Appraisal Committee, section 41 B for compulsory disclosure of information including safety policy and on-site emergency plan and disaster control measures, section 41 C for medical examination, health, records & qualified supervisors, section 41D for Government's power to appoint inquiry committee, section 41E for emergency standards, section 41F for permissible limits of toxic exposures, section 41G for worker's participation in safety management and section 41H for right of workers to warn about imminent danger.
4. Amendments of sections 4, 9 (raising the powers of inspectors), 13, 16, 18, 19, 23, 25, 28, 29, 30, 31, 32, 36A, 64, 70, 71, 80, 87, 89, 90, 91A, 92, 94, 95, 96, 97, 98, 99, 115 and 119. The remarkable amendment is the heavy increase in penalties extending upto Rs. 2 lakhs and Rs. 5000 daily fine, imprisonment upto 10 years and minimum fine of Rs 5000 in case of serious injuries and Rs. 25000 in case of death.
5. Substitutions of section 36 and 38.
6. Omission of section 100 for nomination of occupier.

Therefore, now, looking to the passing of above Act of 1987, the factory managers and occupiers must run their factories strictly according to the law to avoid dire consequences.

1.11 The Gujarat Factories (Amendment) Rules, 1995 : ,

To give effect to the Factories (Amendment) Act 1987, the Government of Gujarat published the draft of Gujarat Factories (Amendment) Rules on 28-10-1993 which became enforceable from 15-2-1995.

First time the provisions regarding competent person, work environment record, health & safety policy, safety committee, centrifugal machines, power press, shears, slitters, & guillotine machines, reaction vessels & kettles, polymerising and curing machines, thermic fluid heaters, fragile roofs, ovens & dryers, ship building, repair & breaking, hazardous chemicals & processes, disclosure of information, qualified supervisors, ambulance van, carcinogenic dye intermediates, asbestos, chemical works, solvent extraction plants, CS, plants, high noise, pottery and foundry were introduced by these rules.

Old provisions regarding ventilation &: temperature, textile machinery, pressure vessels and fire protection were enlarged with further details.

New forms No. IB, 4B, 21A, 26,27, 32, 33, & 37 added. Old 25 forms were substituted by other forms with more details.

Major provisions are as under :

1. Testing or examination of pressure vessels, lifting m/cs., structural stability, dangerous m/ cs., dangerous fumes, and exhaust system by competent persons.
2. Work environment monitoring & record in Form No. 37.
3. Details of safety policy, safety committee, application for site appraisal, test reports of pressure vessels, accident reports. Annual Reports etc.
4. Identification of major hazard chemicals, processes and plant (Rule 68J).
5. Machine wise guarding for textile machinery, power presses and shears.
6. Detailed provisions for fire protection including calculation of fire load.
7. Safety measures to control accidents in ship building, breaking & repairs.
8. Medical care and record for workers.
9. Qualified supervisors for hazardous process.
10. Detailed provisions (new schedules u/r 102) for manufacture of chemicals, electroplating, asbestos, CS, pottery, foundry, carcinogenic dyes, and solvent extraction plant.

For details see Reference No. 10 at the end-of this chapter.

2 THE ACT AND RULES AT A GLANCE

A framework of the Factories Act; 1948 (Amended up to 1987) and the Gujarat Factories Rules, 1963 (amended up to 1995) is given in Table 27.1 to understand the subject matter and inter-relation of Sections, Rules, Schedules and Forms in brief. This helps in speedy search of subjects. The latest Statute book for these provisions must be kept in each factory and with each .Safety Officer.

Table 27.1 : Framework of the Factories Act & Rules

Sec	Subject	Rule No.	Sch.	Form No.
	Chapter – 1 : Preliminary			
1	Title, extent & commencement	1		
2	Interpretation (Definitions) Hazardous processes	2, 2A	1st Sch.	4A, 26, 27
3	Reference to time	-		
4	Power to declare one or more factories	-		
5	Power to exempt during public emergency	-		
6	Drawing, licence and Registration	3 to 11, 3A to 3D	-	1, 1A
7	Notice by Occupier	12, 12A	-	2, 3A
7A	General duties of the occupier including work monitoring and health & safety policy.	12B, 12C	-	37
7B	General duties of manufactures etc.			
	Chapter - 2 : Inspecting Staff			
8	Inspectors	13		
9	Power of Inspectors	14		
10	Certifying Surgeons	15		5, 20, 27A, 30, 32, 33
	Chapter – 3 : Health			
11	Cleanliness	16, 17, 17A	Sch.	7
12	Waste disposal & Effluent.	18		
13	Ventilation & Temperature	18A	Sch.	
14	Dust & Fume	-		26 A

15	Humidification	19 to 29	Sch.	6
16	Over crowding	-		
17	Lighting	30 to 34	Sch.	
18	Drinking Water	35 to 40		
19	Latrines & Urinals	41 to 50		
20	Spittoon	51 to 53		
	Chapter -4 : Safety			
21	Fencing of Machinery	54	1 to 7	8
22	Work near moving machinery	55, 55A, 56		8
23	Work near dangerous machines	57		
24	Power cutting devices	-		
25	Self acting machines	-		
26	Casing of new machinery	-		
27	Work near cotton openers	-		
28	Hoists & lifts	58, 59	Sch.	9
29	Lifting machines, tackles etc.	60, 60 A		10
30	Revolving machinery	-		
31	Pressure plant.	61, 61A, 61B		11, 11A
32	Floors, stairs, means of access			
33	Pits, sumps, floor Opening etc.			
34	Excessive weights			
35	Protection of eyes			
36	Dangerous gas, fumes etc.			
36A	Portable electric light			
37	Explosive / inflame mable gas etc.			
38	Fire			
39	Defective parts, stability etc.			
40	Safety of building & machinery			
40A	Maintenance of building			
40B	Safety Officer			
41	Power to make rules			
	Chapter -4A : Hazardous Process			
41A	Site appraisal committee			
41B	Disclosure of information			
41C	Medical examination, records and supervisors			
41D	Inquiry committee			
41E	Emergency Standards			
41F	Permissible exposure limits			
41G	Safety committee			
41H	Imminent danger.			
	Chapter – 5 : Welfare			
42	Washing facilities			
43	Storing & drying clothing			
44	Sitting			
45	First – Aid			
46	Canteen			
47	Shelter, Rest room, Lunch room			
48	Creche			
49	Welfare Officer			

50	Power to make rules			
	Chapter – 6 : Working Hours			
51	Weekly hours			
52	Weekly holidays			
53	Compensatory holidays			
54	Daily hours			
55	Rest intervals			
56	Spread over			
57	Night shifts			
58	Overlapping shifts			
59	Wages for overtime			
60	Double employment			
61	Notice of working hours			
62	Register of adult workers			
63	Work according to notice and Register			
64	Exempting rules			
65	Exempting orders			
66	Employment of Women	91 A		
	Chapter - 7			
67	Children – not allowed			
68	Non – adult workers.			
69	Fitness certificate			
70	Effect of certificate			
71	Working hours for children			
72	Notice of working hours for children			
73	Register of child workers			
74	Work according to notice and register			
75	Medical Examination			
76	Power to make rules			
77	Employment of Children Act applicable			
	Chapter - 8 : Leave with wages			
78	Applicability			
79	Annual leave with wages			
80	Wages during leave period			
81	Advance payment			
82	Unpaid wages			
83	Power to make rules			
84	Power to exempt factories			
	Chapter – 9 : Special Provisions			
85	Power to apply the Act to certain premises			
86	Power to exempt public institutions			
87	Dangerous operations			
87A	Power to prohibit due to serious hazard			
88	Notice of accidents			
88A	Notice of dangerous occurrences			
89	Notice of diseases			
90	Inquiry for accident or disease			
91	Power to take samples			
91A	Safety & Health surveys			

	Chapter – 10 : Penalties & Procedures			
92	General penalty for offences			
93	Owner's liability in certain cases			
94	Enhanced penalty			
95	Penalty for obstructing Inspector			
96	Penalty for offence u/s 91			
96A	Penalty for offence u/s 41B, C&H			
97	Offences by workers			
98	Penalty for using false certificate of fitness			
99	Penalty for double employment of child.			
100	Omitted in 1987.			
101	Exemption of liability.			
102	Power of court to make orders			
103	Presumption as to employment			
104	Onus as to age.			
104 A	Limits of practicable etc.			
105	Cognisance of offences.			
106	Limitation of prosecutions			
106 A	Jurisdiction of a court.			
	Chapter 11 : Supplemental			
107	Appeals			
108	Display of notices			
109	Service of notices			
110	Returns			
111	Obligations of workers			
111 A	Right of workers			
112	General power to make rules			
113	Power of centre to give directions			
114	No charge for facilities etc.			
115	Publication of rules			
116	Application of Act to Govt. factories			
117	Protection to persons acting under this Act.			
118, 118 A	Not to disclose information.			
119	Effect of this Act,			
120	Repeal and savings			

3 SUBJECTS OF THE SCHEDULES

The Schedules under the Factories Act and The Gujarat Factories Rules contain exhaustive details of the provisions regarding safety and health measures. The subjects of these Schedules are mentioned in Table 27.2.

Table 27.2 : Schedules under the GFR

Sr. No.	Subject of the Schedule	The Number of			
		Sch.	Rule	Sec.	Form
1	Hazardous industries.	1^{st}	-	2 (cb)	-
2	Hazardous chemicals, TLVs & STELs	2^{nd}	-	41F	-
3	Notifiable Diseases	3^{rd}	-	89, 90	-
4	Conditional exemption of factories from painting, colour/ white washing.	Sch.	16 17	11	7
5	Dry / wet bulb temperature in room.	Sch.	18A	13	-
6	When humidification not allowed	Sch.	19	15	6
7	Exemption from minimum lighting	Sch.	34	17	-
8	Textile machinery	1	54	21	-
9	Cottong Ginning machinery	2	54	21	-
10	Wood-working machinery	3	54	21	-
11	Rubber mills	4	54	21	-
12	Centrifugal machines	5	54	21	-
13	Power presses	6	54	21	-
14	Shears, slitters and Guillotine m/c	7	54	21	-
15	Exemption to Hoists & lifts	Sch.	59	28	9
16	Excessive weights (limits)	Sch.	62	34	-
17	Protection of eyes	1, 2	63	35	-
18	Portable FEEs	1	66A	38	-
19	Equipment with Trailer pump	2	66A	38	-
20	List of Hazardous (MAH) chemicals	1	68J	41	-
21	Threshold Quantity for Isolated Storage	2	68J	41	-
22	Threshold Quantity of Hazardous (MAH) chemicals.	3	68J	41	-
23	Hazardous processes/ operations.	4	68J	41	-
24	Safety data sheet (MSDS)	5	68J	41	-
25	Notification of Major Accident.	6	68J	41	-
26	Notification of Activity / site	7	68J	41	-
27	Safety Report	8	68J	41A	-
28	Equipment in Health centre	Sch.	68J	41C	-
29	Facility for storing / drying clothing.	Sch.	69A	43	-
30	Confidential positions.	Sch.	89	64	-
31	Exemption from working hours.	Sch.	91	64	-
32	Aerated water	1	102	87	-
33	Electrolytic plating.	2	102	87	20, 27A
34	Electric accumulators	3	102	87	-
35	Glass manufacture	4	102	87	-
36	Grinding / Glazing of metals.	5	102	87	26A
37	Lead and lead compounds	6	102	87	30
38	Generation of petroleum gas	7	102	87	-
39	Air blasting	8	102	87	26A
40	Liming / Tanning of raw hides.	9	102	87	-
41	Chromic acid or bi-chromates	10	102	87	-
42	Carcinogenic Dye intermediates	11	102	87	20, 33
43	Acids or Alkalis	12	102	87	-

44	Toxic and inflammable solvents	13	102	87	-
45	Manufacturer/ use of CS_2 and H_2S	14	102	87	-
46	Dangerous pesticides	15	102	87	-
47	Water electrolysis and O_2 and H_2	16	102	87	-
48	Asbestos or its articles	17	102	87	20, 26A, 27A
49	Stone or Free silica	18	102	87	26A
50	Chemical works.	19	102	87	-
51	Benzene	20	102	87	-
52	Solvent Extraction plant	21	102	87	-
53	CS_2 plant.	22	102	87	-
54	High Noise levels	23	102	87	-
55	Gas welding of cutting	24	102	87	-
56	Pottery	25	102	87	30
57	Foundry	26	102	87	20, 26A, 27A
58	Cotton dust	27	102	87	
59	Dangerous Occurrences.	Sch.	103	88 A	21A

4 SUBJECTS OF THE FORMS

Some 46 forms have been prescribed under the Gujarat Factories Rules, 1963. To know their subjects and ease for implementation, their headlines are mentioned in Table 27.3

Table 27.3 : Forms under the GFR

Form No.	Subject	Rule No
1	Permission to construct or start a factory, to be submitted in duplicate with plans	3
1A	Stability certificate	3C
1B	Application to the site appraisal committee to be submitted in 15 copies	68-I
2	Application for Registration and licence, to be submitted to triplicate.	4
3	Application for renewal of licence, to be submitted in duplicate.	4, 7
3A	Notice of change of Manager,	12 A
4	Licence to work as a factory	5
4 A	Certificate of competency.	2A
5	Fitness certificate for young person.	15
6	Humidity Register	23
7	Record of Limewashing, Painting etc.	17
8	Register of workers attending moving machinery.	54, 55
9	Test report of hoist of lift.	58
10	Test report of lifting machines	60
11	Test report of pressure vessel	61
11A	Test report of water sealed gas holder.	61 A
12	Register of compensatory holidays	84
13	Overtime register for exempted workers.	85
14	Notice of working hours of adults	87

15	Register of adults workers	88
16	Notice of working hours for child workers	92
17	Register of child workers	93
18	Resister of leave with wages	94
19	Leave books (copy of Form No. 18) for workers	95
20	Health Register.	15, 102
21	Accident report for death or injury	103
21A	Report of dangerous occurrence not resulting in injury	103
22	Notice of poisoning or disease.	104
23	Abstract of the Act & Rules.	106
24	Annual return under the F.A. and other Acts	107
25	Half yearly return	107
26	Application for competency certificate (Person)	2A
26A	Test report of local exhaust ventilation (Dust/ Fume Extraction System).	102
27	Application for competency certificate (Institution)	2A
27A	Fitness certificate	102
29	Muster roll	110
29	Register of Accident / occurrences.	111
30	Special fitness certificate (Lead compound Sch. 6)	102
31	Inspection Books.	112
32	Health Register.	68T, 102
33	Fitness certificate (Hazardous process/ operation)	68T, 102
34	Deleted	-
35	Nomination for leave-wages	100
36	Identity card	110A
37	Format for work environment monitoring.	12B.

5 SOME ABSTRACT OF THE ACT AND RULES

Actually the structure (tables) given in the foregoing part gives also the abstract of safety, health and welfare provisions stating the subject of each section, rule, schedule and the form in one line. This is most useful to study the whole law on a particular topic at a time.

See the statutory Form No. 23 for the Abstract of the Factories Act 1948 and the Gujarat Factories Rules, 1963. This abstract is readily available and is to be displayed on the notice board in each factory. Therefore it-is not repeated here.

Most of the chapters of this book also provide relevant subject under the heading of Statutory Provisions. Thus the abstract of the Factories Act and Rules is already divided chapter wise at proper places. See the theme of each chapter to search the relevant statutory provisions.

See Part 6.3.8 of Chapter-6 and Part 2 of Chapter-? for 'Statutory requirements under the Act & rules.

Notwithstanding that a brief abstract of the provisions pertaining to Safety, Health and Welfare is given below. For full details the readers are advised to refer the Statute Book.

5.1 Safety Provisions :

Chapter 4 and 4A (sections 21 to 41H) and chapter 9 (sections 87 to 91 A) of the Factories Act 1948 and rules made there under (Rule 54 to 68Y and 102 to 104 of the Gujarat Factories Rules 1963) give provisions pertaining to industrial safety. Some major aspects are as under:

Machine Guarding : All moving parts of prime mover, flywheel, turbine, lathe, motor, generator, transmission machinery (shaft, wheel, pulley, belt, coupling etc.) should be securely fenced by guards. Only trained workers are allowed to work (test, lubricate, examine etc.) near machinery in motion and without guard. No women or young person is allowed for such work. Self acting machines (e.g. planning m/c) revolving machines, (e.g. grinding wheel, revolving basket, etc.) dangerous machines (power presses, milling m/cs, guillotine m/cs, circular saws, platen printing m/cs, hoists, lifts and lifting m/cs) and ginning, textile, wood-working and rubber-mill machines and their dangerous parts must be securely guarded and interlocked as prescribed.

Pressure Plant : Section 31 -and Rule 61, 61 A & 61B provide that all vessels operating at a pressure higher than the atmospheric pressure should be considered as "pressure vessels' and examined externally at 6 months, internally at I year and hydraulically at 2 years (4 years for vessel in continuous process) by a competent person. Safety valve, pressure reducing valve or pressure regulator, rupture disk, pressure gauge, stop valve, drain cock etc. should be provided and well maintained. Safe pressure limit shall never be exceeded. Pressure reduction or repair shall be carried out as suggested by a competent person.

Floors, Stairs, Means of Access shall be safely maintained and steps, platforms, fencing; handrails etc. shall be provided.

Pits, Sumps, Vessels, Tarik, Floor- openings etc. shall be securely covered, fenced or guarded.

Excessive weights are prescribed under rule 62 for male, female and use of hand cart No person will lift, carry or move more weight than that. Eyes, shall be protected from flying particles or excessive light as per schedule 1 & 2 under rule 63.

Precautions against dangerous fumes, gases, dust, vapour etc. are necessary. Manhole of prescribed air/gas test, safety work-permit, safety belt, size, enclosure, exhaust/venting, prevention or removal of toxic or inflammable substance etc. are prescribed.

Fire Precaution under section 38 and rules 66, 66A and 67 require measures to prevent out break of fire and its spread, safe means of escape, fire extinguishers, trained staff, hydrants, sprinklers, trailer pump etc.

Safety Officers are required for all factories employing more than 1000 workers and also by those hazardous factories notified by the Government. The Gujarat Safety Officers (duties, qualifications and conditions of service) Rules, 1983 prescribe their duties, status, qualification and need of possessing degree or diploma in Industrial Safety.

Hazardous industries are listed in the 1st Schedule of the Act, hazardous processes in 4th Schedule of Rule 68J(GFR) and hazardous chemicals in Schedules I to 3 of the Rule 68J(GFR). Provision of site appraisal committee is not implemented by many states including Gujarat. Information of hazards and control measures should be given to workers, inspectors and the public. Onsite & Offsite emergency plans, qualified supervisors, medical examinations and health records, occupational health centre, factory medical officer, ambulance van, control of permissible exposure limits (TLV & STEL) given in 2nd

Schedule are required for hazardous factories. Safety policy, safety committee and removal of imminent danger are prescribed.

Safety audit is to be carried out internally once in a year and externally once in two years. Public likely to be affected out side the site is to be informed about major accident hazard and "DOS" and "Donts" for that. Occupier has to dispose off all hazardous material on site before closure of manufacturing process and to inform the inspector (Notification dated 2-6-2006).

For workers in hazardous process pre-employment and six- monthly periodical medical examinations by a factory medical officer, report in form No: 32, 33, qualified supervisors, occupational health centre for workers more than 50 and ambulance van for workers required.. List of notifiable diseases is given in the 3rd Schedule of the Act. It should be reported in Form No. 22 u/r 104. Rule 102 requires medical examination, local exhaust ventilation, washing facilities, protective clothing, medical requisites, spacing, cloakroom, mess room, vacuum cleaning, cautionary notices, prohibition of food, drink etc. in workrooms, waste disposal method etc. under different schedules.

Notices of Accidents and Diseases are required in form No. 21 & 22. Dangerous occurrences (Fire, explosion, gas leak, collapse etc.) are also to be reported in form No. 21A.

Special provisions are prescribed for dangerous machines, reaction vessels, polymerising & curing machines,, thermic fluid heaters, fragile roofs, ovens & driers, ship building, repairing and breaking, hazardous chemicals, processes and chemical works, electroplating, carcinogenic dye-intermediates, asbestos, solvent extraction plants, CS, plants, high noise, pottery, foundry and cotton dust. Amendments of 1995 in GFR provide details thereof. (See Ref No.lO at the end).

5.2 Health Provisions :

Chapter 3 (Sections II to 20) chapter 4A (section 41C) and chapter 9 (Sections 89 to 91A) of the Act and rules made there under (Rule 16 to 53, 68R to 68X, 102 and 104 GFR) give provisions pertaining to occupational health and hygiene. Some major aspects are as under :

Factory should be kept clean, white washed, or colour washed. Doors, windows etc. shall be painted. Waste & effluents be rendered innocuous. Room temperature should be less than 30°C (80°F), air movement more than 30 mt /min, ventilating opening more than 15% of the floor area and mechanical ventilation (air changes) should be six times the workroom volume per hour. Dust & fumes should be removed by exhaust ventilation. Artificial humidification should be controlled as per the table of dry and wet bulb temperatures. No overcrowding permitted. Breath- air volume per worker should be at least 14.2 m3 with room height limited to 4.2 mt. Natural and artificial lighting is required with avoidance of glare, shadows and eye-strain. Light intensity may very from 20 to 1000 Lux depending on nature of work i.e. depth of observation required. Drinking water should be sufficient, clean and cool where more than 250 workers employed. At least one water centre for 150 workers required. Latrines, urinals and spittoons should be clean and in hygienic condition. For males and females, latrines and urinal shall be of prescribed number and dimensions. They shall be whitewashed every four months.

5.3 Welfare Provisions :

Chapter 5 (Sections 42 to 50) and rules made thereunder (69 to 83A, GFR) give provisions pertaining to welfare of workers. Some major aspects are as under:

Facilities of washing/bathing, storing & drying, clothing, sitting, first-aid, ambulance room, canteen, shelters, rest room, lunch room, creche and welfare officers are required. One first-aid box for every 150 workers, ambulance room for more than 500 workers, canteen for > 250, restroom & lunch room for > 150, creche for > 30 female workers and welfare officers for > 500 workers are required. Welfare Officers (Recruitment and Conditions of service) (Gujarat) Rules, 1963 prescribe number of welfare officers, their qualifications, duties, etc. The size and type of rooms for canteen, rest/lunch room, creche ambulance etc. are also prescribed.

For other chapters and the provisions see the full text of the Act.

6 THE CASE LAW

Before studying any law and citations on it (ie case law) it is important to know the meaning of following legal words. -

1. Law, common law and natural justice.
2. Legislation, legislative process, enactment, statute, statutory, mandatory, notification and ordinance.
3. Bill and statement of objects and reasons.
4. Act, preamble and code.
5. Sections, rules, regulations, schedules & forms.
6. Proviso, exception, exemption, explanation, not withstanding that and save as otherwise provided.
7. Penal section, fine, imprisionment, responsibility, occupier and manager.

All offences under the Factories Act and Rules fall under the category of **absolute criminal liability**, which requires no mens rea or guilty intention to be proved (AIR 1966 Mad 448 and 1964 Vol. 2 LLJ, 456). Out of many decided cases a few citations on safety and halth matters are mentioned below to highlight the case law.

6.1 Citations under the Factories Act :

1 Object of the Act is for the benefit and welfare of the labour class only. AIR 1956 Born. 219.

2 Interpretation of the Act should be liberal and beneficial AIR 1956 Born. 33, AIR 1966 Guj. 96, AIR 1965, SC 639.

3 Limitation of prosecution u/s 106 - Knowledge of offence - Date of receipt of accident report by the Inspector is not the date of knowledge of dangerous occurrence. It is the actual date of his personal knowledge. AIR 1973 SC 309.

4 Where the word 'managei, is used specifically, generally he should be taken as accused though the occupier can be selected instead of manager u/s 52, SC ruling 1965 Vol. I LLJ 419.

5 Power presses : 1965 Vol. 2 LLJ 472 where section 21- was discussed, 1966 Vol. 2 LLJ 10, 1972 LIC 949, 1966 Vol. I LLJ 280.

6. Transmission Machinery : Height above 15 feet was considered safe by position for which no fencing necessary. 1965 Vol. 2 LLJ 200. In another case height of 9 feet was considered safe for which no-under guard was necessary 1966 Vol. I LLJ 304.

7. Drill machine : Defence that the factory inspector had not pointed out or suggested for guard, it was not provided, cannot be accepted. It was an absolute duty to provide the guard. 1966 Vol. 1 LLJ 705.

8. Calendar machine : Nip guard was necessary, 1966 Vol. 2 LLJ 867.

9. Spur-gear wheel in oil mill : Defence that the guard was provided but some one else removed it, was not accepted. The words "while the machinery is in motion its dangerous parts shall be securely fenced." were sufficient to constitute the offence u/s 21(l)(iv)(c). State of Gujarat v/ s Jethalal Ghelabhai. SC ruling, 1964, Vol. I LLJ 389.

10. It is the duty of the employer who is running a factory to make every sort of protections for the safety of the employees. AIR 1966 Mad 380.

11. It cannot be said that if something goes wrong with the machinery while it is in motion and a part of it slips down, there is no obligation on the employer to protect aworkman from injury arising under such circumstances. The basic idea is that the safeguard must be in position so that the rotating or moving part of the machinery is incapable or causing any injury. 1966 Vol. I LLJ 304.

12. It is an absolute obligation under the Factories Act to securely fence dangerous parts of machinery. The statute does not say that they should be fenced only if it is commercially practicable or mechanically possible. AIR 1966 MP 324, (1966) 2LLJ 867.

13. The obligation that a dangerous machine shall be securely fenced by safeguards of substantial construction is absolute, and should be complied with regard to all parts of the machinery. (1965) 2 LLJ 472.

14. Manager/Occupier cannot escape conviction for failure in securely fencing every dangerous part of machinery unless he has satisfied all requirements of section 22 (1) of the Act. (1965) I LLJ 528.

15. Mere fact that the die was not provided with any guard by its manufacture, no effective safety guards could be provided to the die without impairing the working of the machine, cannot affect the employer's responsibility under the law to securely fence the die by safety guards of substantial construction. (196465) 26 FJR 162.

16. Section 21(1) (iv) (c) of the Act requires not only that the dangerous part of a machine shall be securely fenced by safeguards, but also that the safeguards are kept in position when the machine is working. AIR 1964 SC 779, (1964) I LLJ 389.

17. The obligation of the occupier to securely fence the dangerous parts of the machinery is absolute whether those parts may be in motion or use or not. (1962) I LLJ 607.

18. Transmission machinery must be securely fenced unless the same, by reason of its position or construction is safe to every person employed in the factory as it would be if it were securely fenced. AIR 1960 Born. 1.

19. In order to claim the benefit of proviso to section 21 (1) (iv) of the .Act for getting the occasion excluded, it is a necessary condition that on such occasion the necessary adjustment operation to the moving part of the machinery must be done by a worker specified in section 22 of the Act in the manner provided therein. (1965) I LLJ 528.

20. Where instead of complying with the statutory requirements contained in section 24 of the Act and providing the equipment indicated therein, it had been the practice in the concerned factory to effect the movement of the belt with some rod, or crude contrivance which was unsafe, the employer was guilty of negligence under the said section. (1964-65) 26 FJR 153.

21. An owner or occupier of a factory cannot plead in his favour ignorance of the law as contained in the provisions of section 28(1) (e) of the Act. He was bound to provide interlocking arrangement required., (1964) 1"LLJ 689.

22. Only two diagonally opposite chains are necessary and sufficient for working of the tackle. If fourth chain of tackle is allowed to remain in a state of disrepair, the manager of the factory does not contravene the provisions of section 29 (1) (a) (ii) of the Act. (1969) Lab I.C. 783.

23. Failure to cover a pit inside the factory having inherent danger amounts to violation of section 33 of the Act (1967) 2 LLJ 616.

24. No manufacturing process shall be carried on in any building until a certificate of stability of the building has been obtained. Failure to do this is an offence. AIR 1957 Allh. 343.

25. The defence undersection 101 of the Act will not be available to an owner of a factory unless he has proved that he had used due diligence to enforce the execution of the Act. AIR 1964 SC 779.

26. Any person found working in the factory can be taken as employed in the factory until it is proved contrary. 1964 (1) LLJ 575.

27. Failure to comply with the provision of sec. 14 is a 'continuing offence'. Prior knowledge of the offence by the Inspector is not a bar in filing a complaint subsequently (1952-53) 4 FJR 231.

    Failure to construct a dustproof husk chamber as required under section 14 is a continuing offence. AIR 1962 MP 311. Omission to securely fence fermenting vats is a continuing offence. AIR 1964 Guj. 125, (1964) 5 GLR 29. Omission to provide a canteen is a continuing offence. AIR 1957 All ere (DB). Carrying on a manufacturing process in a building in the absence of a certificate of suitability of the. building as required by the rules is also a continuing offence. AIR 1955 Born. 161 (DB.)

28. The plea of ignorance of law is not available to the accused under section 28(1) of the Act. 1964 (1) LLJ. 689.

29. Fencing and safeguard should not be such as can be disturbed and removed by a workman. 1972 Mah LJ. 279, 41 FJR 165.

30. A machinery or part thereof is dangerous if in the ordinary course of its working, danger may reasonably be anticipated from it when working without protection, taking into account the various factors incidental to its working, including the carelessness of the workman, AIR 1969 MP 110.

31. S.2 (m), 2 (k)(i) and 2(1) - Factory", meaning of - Sun cured tobacco leaves subjected to processes of moistening, stripping and packing in a company's premises with a view to their use and transport to company's main factory for manufacturing cigarettes- More than 20 persons under supervision of management working in premises - Held that the manufacturing process was carried on in premises and the persons employed Were workers and premises a factory. Lab IC 1970 S C 56A.

32. S. 2 (k)- "Manufacturing process" - Process of cleaning Water and storing and supplying it by pumping is a manufacturing process. Lab IC 1972 970F Raj.

33. Ss. 33 &2 (m) - Contravention of Section 33 in regard to a pit which is in the environments of the factory - Necessary proof. Lab IC 1972 772 Born.

34. S. 2 (k) (i) - "Manufacturing process" - Rice mill - Use of huller and sheller for converting paddy into rice and polishing it* is a manufacturing process Lab IC 1976, 1387 (Kant).

35. S. 92 - Karnataka Factories Rules. 1969 Allegation that first aid box was not maintained according to Rules - Prosecution must prove what was wanting in contents of box Lab IC 1976,538D (Kant).

36. S. 21 (1) (iv) (c) read with Bombay Factory Rules (1950), Sch. I, Chap. IV, R. 54 (2) and (3) - Compliance with safety measures is mandatory- Whether employer had foreseen casualty is totally irrelevent Lab IC 1978, 1220 Born.

37. S. 2 (m) and S. 103 - Ten workers found inside an automobile workshop during working hours - Plea that two of them were workers in a rice mill not acceptable Lab IC 1979, 159A Mad NOC.

38. S. 2(m), 92 and Rule 4, GFR-'Factory'- meaning of - Construction work - Temparory work done with aid of power at certain places do not amount to 'factory' within meaning of Section 2(m) - Prevailing nature of work to be taken into account- Contract between company and contractor regarding work and labour manufacture of certain materials on same premises - Temporary use for manufacturing such articles with aid of power will not include premises in the term factory. FLR 1980(41)75, Gujarat.

39. S. 2(g), 2(k), 2(m) - Manufacturing processMeaning of-lroning of stitched clothes with the aid of power by tailoring firms, held, is an integral part of manufacturing process LLN 1985 Vol-ll 101.

40. S. 21(l)(iv)(c) & 92- Injury to worker due to alleged failure to securely fence dangerous part of machinery- Evidence of Factory Inspector silent on vital point- In the circumstances order of conviction of appellant- manager set aside LLN 1986 Vol 1 332.

41. S. 2(k) - Petrol pump service station carrying on business of sale of petrol, diesel, lubricants etc. and servicing of vehicles is a manufacturing process LLN 1987 Vol 1 912.

42. S 2(k)- Dairy farm- filling of milk pots for distribution- Also electric pump used for lifting water in farm- Held, manufacturing process 1987 Vol II 704.

43. S.2(l) - Effect of addition of words "including a contractor".

The effect of including the said words in the definition of "worker" is that even a worker engaged through a contractor and working in a factory falls within the definition of worker for the purposes of Factories Act. This was done evidently with a view to ensure that the benefits of the several regulatory and welfare measures provided by the Act extends to such contract labour also.

Govt. of A.P. vs. Bhadrachalam Paper Boards Ltd., 1990 (60) FLR 517 (A.P. - D.B.).

44. Workers-Staff engaged in the clerical work in the factory premises- Whether 'workers' within the meaning of section 2(1) of the Act? Yes. State (By Inspector of Factories, Guddalore) vs. A.K. GangllU, 1993 LLR 701 = 1993(67) FLR 627 = 1993 II CLR 57 = 1993 I LLN 791 (Mad. HC).

45. Conviction and sentence of respondent on his pleading of offence under section 92 providing minimum sentence of fine not less than 25000Trial court imposed fine of Rs. 200 onlyWhether order is illegal and perverse? Yes.

State of Glljarat vs. B.S. "niakkar, Manager, Diguijay Cement Co. Ltd., 1993 LLR 843 = 1993 (67) FLR 1134 (Guj. HC). See also 1991 (1) 32 (1) GLR71 and 1992 II GLR 229 for State of Gujarat v/s Dr. CK Patel

46. The period of limitation for prosecution in contravening provisions of the Factory Act will be computed from the date of inspection and disclosure of offence.

State of Gujarat vs MIT & MIR Pvt. Ltd. Surat, ,1994 LLR 116 (Guj. HC)

47. Appointment of certain number of safety officers in a factory having chemical plant and blast furnace is a statutory obligation on the part of the employer.

Tata Iron and Steel Co. Ltd. vs Inspector of Factories, Jamshedpur Circle No. I, Jamshedpur and .Others, 1995 LLR 684=1995 II LLN 474 (Pat. HC).

48. Employees of administrative accounts section of a factory will be eligible for overtime.

Chief General Manager, Telecom Factory, Bombay & Ors. vs. All India Telecom Engg. Employees Union & Ors., 1996 LLR 333 (Born. HC).

49. In the event of conflict between the provisions of standing orders and Factories Act, the latter will prevail.

Maharashtra General Kamgar Union vs. Bharat Petroleum Corp. Ltd. & Ors., 1996 LLR 900 (Born. HC).

50. Failure to provide safety electrical devices (earthing, rubber gloves, shoes etc.) resulting into death of a casual worker will make the employer liable for prosecution and fine. The High Court converted the order of acquittal into a fine of Rs. 50000 (in default, impris.onment for 3 months) each to the manager and occupier, accused, and directed to pay Rs. 50000 to the legal representatives of the deceased worker u/s 357(4) of the Cr. P. C.

State of Karnataka vs. M. Siddappaq & Amr., 1997 LLR 411 (Karn. HC).

51. Factories Act, 1948 - S.2 (n) - Occupier in case of a company.

Occupier in case of a company must be one of the Directors. As such relief claiming appointment of a person other than a Director as an occupier cannot be granted.

Tata Oil Mills Co. Ltd. vs. State of U.P., 1997 (2) LLN 681 (All- D.B.).

52. Factories Act, 1948-S.92 read with Rule 61(1)(c)(i) – Punishment for breach of safety measures.

Respondent runs a factory and the Factory Inspector found that the plant was not fitted with necessary safely valve in contravention of the aforesaid statutory provisions. On a complaint. Metropolitan Magistrate fined him Rs. 500/- on his pleading guilty. Hence this appeal for enhancement of sentence.

Held: Factory owner guilty of contravention of safety measures has to be dealt with severally and seriously even on his pleading guilty to the charge. The workmen exposed to such unsafe working conditions in such factories can be said to be their exploitation by owner of such factories. The sentence of fine of Rs.500/- is enhanced to Rs. 5000/-.

State of Gujarat vs. Sandeep Bhandari 1997 I CLR 1048 (Guj. H.C.).

53 Factories Act, 1948- S.92- Karnataka Factories Rules, 1969- Rule 86- Statutory duty not compiled with.

This is an appeal against an order of acquittal of respondent accused for an offence under S.92 of the Act for contravention of Rule 86. Facts are that worker in the factory of the respondent received electrical shock and died on the spot. It is held that there was sufficient and clinching evidence on record to show that the accused did not provide for rubber gloves and rubber shoes to deceased worker and further that electric installations were not properly maintained by the accused, there was no justification on the part of Magistrate to hold accused not guilty.

State of Karnataka v. M. siddappa 1997 I CLR 705 (Kam.H.C.).

54 How it should be interpreted.

The Act is meant to provide protection to the workers from being exploited by greedy business establishments and it also provides for the improvement of working conditions within the factory premises. Hence a beneficial construction should be given and the provisions of the Act should be so constructed/interpreted so as to achieve its objects i.e., welfare of the workers and their protection from exploitation and unhygienic working conditions in the factory premises. It is also a cardinal principle of interpretation to give effect to the plain, fair and ordinary meaning to the words if such interpretation is not opposed to the intention of the legislature.

Ravi Shankar Sharma vs. State of Rajasthan 1993 L.LC. 987 (Raj. H.C.).

55 S.2(m) - & 2(k)(i) - Stone crashing unit is a factory.

As per the definition of "manufacturing process" as .given in the Act, there can be no doubt that breaking of boulders into chips would be a manufacturing process. For this purpose coming into existence of a new product is not necessary. If that be so, the premises where ten or more persons are working and the operation is carried on with the aid of power has to be regarded as a factory.

M/s. Larsen & Toubro Ltd. vs. State of Orissa 1992 LIC 1513 (On. - D.B.).

56 S.21(l)(i)(iv)(c) and S.92 - Enhancement of sentence.

This criminal appeal is filed for enhancement of sentence of fine of Rs.2000/for an offence punishable under S.92 qf the Factories Act, 1948. It is unfortunate and shocking that the Magistrate failed to note the minimum sentence of fine of Rs.5000/- for the offence. He was even not conscious of the object underlying the beneficial piece of legislation viz. Factories Act, 1948. Such gross defiance of law, prima facie, is serious dereliction of duty and unbecoming on the part of any learned Magistrate. The sentence of fine is enhanced to Rs.5000/-. Action is directed against the Magistrate.

State of Gujarat vs. Ishwarbhai Harkflabhai Patel 1994 II CLR 721(Giij. H.C.).

57 S.36 - (as it stood before its amendment by Act 20 of 1987) - Interpretation of sub-section (5) of S.36 -

There is no absolute duty cast on employer to prevent entry - Burden is on prosecution to prove that employer had not taken all reasonable steps for preventing entry and not on employer to prove that he had taken all reasonable steps. If necessary instructions are issued by employer and worker acts in contravention of those instructions, employer cannot be held responsible for violation of S.36(5).

State of Gujarat vs. Dilipkumar Dahyabhai Patel & Anr. 1995 II CLR 497 (Guj H.C.).

58 S.40-B and W.B. Factories, (Safety Officers) Rules, 1978 - Rule 3(b) - Appointment - Compliance of two pre-conditions

The petitioner, who was appointed as safety officer, challenges, termination of his service to be against the provisions of the Rules.

High Court has not accepted the challenge observing as follows :

Appointment of safety officers, is mandatory on existence of two conditions : (i) wherein 1000 or more workers are ordinarily employed and the State Government issues notification requiring the occupier to appoint safety officer or officers and (ii) wherein the State Government is of opinion wherein manufacturing process is carried which involves risk etc. and issuance of notification in above manner. Issuance of notification is a indispensable condition for employment of safety officers in terms of S.40-B of the Factories Act. In the instant case no such notification was issued. Thus the mandatory requirement of S.40-B cannot be said to have been fulfilled to make employment of the petitioner as Safety Officer within the meaning of clause 3(b) of the Rules of 1978. The termination was thus not violative of the Rules.

Debesh Kumar Bhattacharya vs. Rishra Steel Ltd. & Ors. 1994 II CLR 944 (CaL H.C.).

59 S.41-A - Safety precautions in handling chemicals.

The Union of employees filed writ petition to direct Chief Inspector of Factories to enforce safety precautions in the factory. Inspector of Factories had given certain directions to the management of the factory and thereafter he again visited the factory and submitted report. High Court considered the same and accepted the report and dismissed writ petition. The Union filed this appeal against said order. In appeal it is observed that new complaints regarding atmosphere pollution and provision of insurance cover to employees cannot be entertained as they are not the grievances in the main writ petition.

Addision Paints and Chemicals Ltd. vs. Chief Inspector of Factories 1993 II L.L.N. 728 (Mad.D.B.).

60 Ss82 and 106 - Magistrate dismissing complaint made by Inspector under S.92 on preliminary contention that it was filed beyond period of limitation of three months as prescribed under S.106. In fact complaint was filed within three months of the date on which commission of offence came to knowledge of Inspector - Matter remanded - Practice of disposing of cases on grounds such as (i)complainant absent, (ii) no witnesses examined, or (iii) accused pleading guilty, deprecated.

State ofGujarat vs. Mit and Mir Private Ltd., Swat 1994-1 CLR 149 (Guj. H.C.).

61 S.92 - Karnataka Factor Rules, 1969 - Rules 84 and 88 - Negligent shunting of carriages Occupier not responsible.

Accident took place in Railway Workshop due to negligent shunting of carriages. Occupier is prosecuted for contravention of Rules 84 and 88. He filed this petition praying for quashing of proceedings against him.

Held : Rule 84 prohibits any process of work which is likely to cause risk of bodily injury to be carried on in the factory. It is not complainant's case that the work of shunting which was done within the factory premises was likely to cause risk of bodily injury. Rule 84 is therefore not affected. If due to negligence in carrying out a work which is permissible, an accident takes place, the occupier cannot be held responsible for contravention of Rule 84. So far as Rule 88 is concerned, if bodily injury is caused to a worker not on account of any inherent defect in the construction, situation, operation or maintenance of the means of transport, but on account of negligence of another employee, then it cannot be said that there -is any contravention of Rule 88.

Proceeding of prosecution against petitioner occupier is quashed.

Ramchandra vs. A.R. Vijendra 1994 II CLR 946 (Kar. H.C.).

62 S.92 - Proviso - Minimum sentence is prescribed.

The accused pleaded guilty for having committed offence under S.29(l)(a) and S.29(l)(b) of the Act and was awarded fine of RS.IOO/-. Proviso to S.92 provides that the fine shall not be less than RS.IOOO/-. Merely because the accused pleaded guilty is no reason to award punishment lesser than the minimum.

State of Gujarat vs. Mahavir Prasad Jain 1992 I CLR 863 (Guj. H.C.).

63 Ss.92, 52, 2(m)(ii) and 6 - Opportunity of hearing to find if establishment is a factory.

Prosecution is lodged against the petitioner as failed to comply with the provisions of the Act and Rules. In a challenge against the same, it is urged that before filing the complaint opportunity for hearing should have been given to the petitioner.

Rejecting the submission, it is observed that there is no provision under the Act that before launching prosecution, there should be first determination of the fact whether the establishment is a factory or not. This is a question of fact which can be gone into only during the course of hearing.

Prabhu dayal Gupta vs. State of Bihar 1993 (66) F.L.R. 398 (Pat. H.C.).

64 S.92 and Gujarat Factories Rules - Rule IIO-A Not providing identity cards is serious breach.

Offence of not providing identity cards to workers under S.92 read with Rule IIO-A is not trivial or technical but is grave and serious. For such an offence fine of Rs.20/- is not only unduly lenient and manifestly unjust but is quite ridiculous and travesty of justice. In the circumstances, sentence is enhanced to fine of Rs.l020/-.

State of Gujarat vs. Lallubimi T1iakorb1im Desai 1994 I CLR 610 (Guj. H.C:). S.94 - Plea of guilty not proper.

65 Accused repeated the offence under S.92 of the Act within span of two years. Under S.94 for such repeated offence, the punishment of fine is not less than RS.IOOOO/-. Accused pleaded guilty but in the said plea, the element of defence and justification for wrong doing were incorporated. Such a plea cannot be acted upon. Proceeding remanded.

State of Gujarat vs. Dineshchandra Hirabhai Patel 1993 II CLR 607 (Guj. H.C.).

66 S..94 - Plea of guilty.

The accused gave a plea of guilty in writing wherein he cleverly put some more facts either by way explaining away or justifying the alleged wrong committed by him. Such a plea cannot be said to be plea of guilty at all. Proceeding remanded.

State of Gujarat vs. Harishbhai Veljibhai Tilakkar 1994 II L.L.N. 342 (Guj. H.C.).

67 S.94 - Repeated offences - Judicial Magistrate F.C. has no jurisdiction.

S.94 provides a higher punishment viz. 3 years imprisonment and fine which shall not be less than RS. 10000/- when the offence is repeated. The Judicial Magistrate F.C. cannot impose such sentence and as such he has no jurisdiction to try the said offence. Chief Judicial magistrate is required to try the same.

State of Gujarat vs. Harishbhai Veljibhai TJlakkar 1994 II L.L.N. 342 (Guj. H.C.).

68 High court or Supreme court will not quash FIR lodged by the Factory inspector. S.M. Datta v. State of Gujarat & Anr., 2001 LLR 1076 (SC).

69 An occupier of a factory owned by Government need not be Director of the company. Container Corporation of India Ltd. V. Lt. Governor, Delhi & Ors., 2002 LLR 1068: 2002 LIC 2649: 2002-111 LLJ 447 (Del. HC).

6.2 Section wise Citations :

Table 27.4 is useful to find out section wise citations. Only a few citations are given and many more can be added:

Table 27.4 : Section wise Citations

Section of the Factories Act.	Subject in Brief		Citation.
2 (m)	Substations and zonal stations are not factories.		1972 Lab. I.C. 1438 (SC)
2 (n)	Difference between occupier and owner.		1968 (1) LLJ 12
21	1	Shifting or repairs of machinery are not normal operation in the working go machinery. Therefore the section does not apply.	AIR 1960 Bom 1
	2	Removable guards are not secured guards, Employer is guilty.	AIR 1264 SC 779

	3	Grinding Wheel, dangerous part	1955 (1) ALL ER 870
	4	Dangerous parts.	1966 (1) LLJ 705.
	5	Risk must be reasonably foreseeable.	1965 (2) LLJ 200
	6	Failure of inspector to point out guard is no defence.	1966 (1) LLJ 705
29	Chains: Number necessary for launder.		1969, L.I.C.783
49	Meaning of 'ordinarily' Section 49 can apply to sugar factories.		6 DRL All 297.
62	Failure to maintain register is one offence. If name of any one worker is not therein then, it is failure to maintain register.		1952 (2) LLJ 80
101	Any one means any one and not more of the partners/ directors.		1960 (1) LLJ 42,
105	CIF can file complaint as an inspector.		AIR 1960 ALL 373, 1960 (1) LLJ 288
106	1	Period of limitation	1961 (2) LLJ 717.
	2	Report of accident	1947 LIC 274 (SC)

6.3 SC Judgement on 'Asbestosis' :

Consumer Education & Research Centre & Others v/s. Union of India & Others

The Consumer Education Research Centre filed a writ petition before the Supreme Court under Article 32 of the Constitution by way of public interest litigation highlighting the occupational health hazards and diseases to which the workmen employed in mines and asbestos industries are prone to and seeking remedial measures for the protection of the health of the workers.

ILO Convention 162 was the base of this petition. After going through it and other discussions, the Court held as under -

All the industries are directed :

1. To maintain and keep health record of every worker up to 40 years from the beginning of the employment or 15 years after retirement or cessation whichever is later;
2. The Membrane Filter test, to detect asbestos fibre should be adopted by all the factories or establishments at par with the Metalliferrous Mines Regulations, 1961; and Vienna Convention and Rules issued thereunder;
3. All the factories whether covered by the Employees State Insurance Act or Workmen's Compensation Act or otherwise are directed to compulsorily insure health coverage to every worker;

4. The Union and the State Governments are directed to review the standards of permissible exposure limit value of fibre/ or in tune with the international standards reducing the permissible content as prayed -in the writ petition referred to at the beginning. The review shall be continued after every 10 years and also as an when the ILO gives directions in this behalf consistent with its recommendations or any Conventions;
5. The Union and all the State Governments are directed to consider inclusion of such of those small scale factory or factories or industries to protect health hazards of the workers engaged in the manufacture of asbestos or its ancillary products;
6. The appropriate Inspector of Factories in particular of the State of Gujarat, is directed to send all the workers, examined by the concerned ESI hospital, for re-examination by the National Institute of Occupational Health to detect whether all or any of them are suffering from asbestosis. In case of the positive finding that all or any of them are suffering from the occupational health hazards, each such worker shall be entitled to compensation of a sum of rupees one lakh payable by the concerned factory or industry or establishment within a period of three months from the date of certification by the NIOH.

6.4 SC Judgement on 'Occupier' :

Section 2(n) of the Factories Act was amended in 1987 making any one of the directors of a company to be the occupier. This was appealed in many High Courts and ultimately in the Supreme Court, which gave its judgement on 25-9-1996 in J.K. Industries Ltd. v/s Chief Inspector of Factories and Boilers and Ors., etc. The SC held as under (1996 II CLR 832 and 1996 LLR 961).

1. Factories Act, 1948 - S.2(n). Proviso (ii) - Appellant is a company and runs a factory Whether appellant has to nominate one of the Directors as 'Occupier' or that the company can nominate an other employee as occupier by passing resolution that he will have ultimate control over the affairs of the factory - Held that an occupier of the factory in the case of a company must necessarily be any one of its directors who shall be so notified for the purpose of the Factories Act and that such occupier cannot be any other employee of the company or the factory.
2. S.2(n), Proviso (ii) - As amended by amending Act of 1987 - Whether constitutionally valid Held that the provision is constitutionally valid and is not ultra virus Articles 14, 19(l)(g) and 21 of the Constitution of India.
3. S.2(n) and its proviso (ii) - Whether proviso, detracts from the generality of the main provision - Held that the legislature by providing deeming fiction under proviso (ii) did not detract from the generality of the main provision under S.2(n), but only clarified it.
4. S.2(n) - Meaning of word 'ultimate' appearing therein - Distinction between ultimate control and immediate control - Held that in the case of a company, the ultimate control of the factory always vests in the company, through its Board, of Directors while the Manager or any other employee, of whatever status, can be nominated by the Board of Directors of the owner company to have immediate or day to day or even supervisory control over the affairs of the factory.
5. Ss. 92 and 101 - Third party procedure Safeguards when an occupier is prosecuted Held that an adequate safeguard has been provided under S.I 01, under which for the circumstances mentioned therein, the occupier or manager can absolve himself from the liability if he can establish to the satisfaction of the Court that he is not the real offender but it is the other person charged by him deserves to be punished and that he had been diligent and further that the offence was not committed with his knowledge, consent or connivance.

6.5 SC Judgement - Shriram's Case :

Two judgements were delivered by the Supreme Court (P.N. Bhagwati CJ, D P Madon &GL Oza JJ) in a public interest litigation filed by M C Mehta and another. Petitioner vs. Union of India and others, Respondents and have been reported in (1) AIR 1987 SC 965 and (2) AIR 1987 SC 982. They were also reproduced in the 'Industrial Safety Chronicle' issues of (D.Jul-Sep 1986 and (2) Oct-Dec 1987.

In the First Judgement dated 17-2-1986, eleven stringent conditions were specified by the Court to allow restarting of the plant after oleum leakage from the Shriram Foods and Fertiliser Industries, New Delhi, on 4'h December 1985. This leakage affected a large number of persons both amongst the workmen and the public and according to the petitioner, one advocate died due to inhalation of oleum gas. The prohibiting orders under the Factories Act, safety measures suggested by number of Expert Committees (Manmohan Singh Committee, Nilay Choudhary Committee, Agarwal Committee etc.), inherent hazard or risk in hazardous industries, their need for progress, development and advancement of well being of the people, the interests of the workmen and the community in vicinity to protect their health and safety, effect of closure on @4000 workmen resulting in their unemployment, need of chlorine for Delhi Water Supply undertaking, responsibilities of the occupier and officers and compliance of most of the suggestions, by the factory were considered by the Court and it was held that

1. The management shall fulfil the II conditions set out in Para 20 of the judgement and mentioned below.
2. To pay to the petitioner a sum of RS.IOOOO/- by Shriram as a token of appreciation as well as the cost.

The conditions imposed by the SC in this judgement were:

1. Deposit of Rs.30000/- in the Court to meet the expenses of the members of the expert committee.
2. One operator personally responsible for each safety device.
3. Weekly inspection by the Factory Inspector of safety devices and reporting to the Court.
4. Weekly inspection by the CPCB under the Water Act and Air Act of the effluent and particulate matter and reporting to the Court.
5. Filing of undertaking within 1 week by the management that the officer(s) will be personally responsible for payment of compensation for death or injury in case of future escape of chlorine gas.
6. A committee of 3 Union representatives to look after safety arrangements in the caustic chlorine plant. Necessary training to them within 2 weeks after their nomination.
7. A chart in English and Hindi in each department and at the gate stating the effects of chlorine on human body and treatment measures if affected by the leakage.
8. Training and 6 weekly refresher courses for every worker in the caustic chlorine plant regarding safety precautions for chlorine.
9. Loud speakers all around the factory premises to give timely warning and instructions to the people in vicinity in case of leakage of chlorine gas..
10. Personal protective equipment to the workers and their regular medical check-up.
11. Deposit of Rs.20 lakh in the Court for compensation claims made by or on behalf of the victims of the oleum gas. Furnishing of the bank guarantee for Rs.l5 lakh within 2 weeks.

In the Second Judgement on application by the Shriram Industry to clarify (rather modify) the condition No. 2, 5 and 6 stated above, the Court went through the difficulties contended by the management, and the Court in its judgement dated 10-3-198 modified some of them and held that

1. The permission granted by the Court is subject to the conditions set out in its Order dated l"/ 2-1986 as modified by this Order dated 10- 1986.

2. The measure of compensation in such case (harm caused by the hazardous activity) must be proportionate to the magnitude and capacity of the enterprise to have a deterrent effect. The larger and more prosperous the enterprise, greater must be the amount of such compensation.

6.6 SC Judgement on Radiation Protection :

This judgement was reproduced in October December 1987 issue of Industrial Safety Chronicle of NSC, Mumbai.

In Writ Petition (Civil) No. 761 of 1986 dated 29-4-1987, M K Sharma & others. Petitioners vs. Bharat Electronics Ltd. & others. Respondents, the Supreme Court considered the claim for compensation by workmen on the ground of effects directly flowing out of employment, whether there may be a direct proof or not, and held the desirability of insurance of concerned officers and workmen against the effects of atomic radiation, at the cost of employer.

The Court also directed to send to the petitioner union at reasonable intervals the results of film badge radiation absorption and to maintain the protective lead-shields and bi-annual checks of safety devices by the competent authority.

6.7 TISCO Case of Imprisonment :

Judicial Magistrate First Class Shri Brajeshchandra Za, delivered a strong judgement on 4-10-1999, for breach of Rule 55 A (2&3) of the Bihar Factories Rules, ordering the occupier Shri J. J. Irani and the manager Shri P.N. Roy, both, to undergo imprisonment of two years and. to pay Rs. One lakh as fine (six months more in default of fine). The accused have appealed in the High Court, it is reported.

In TISCO (TATA) factory at Jamshedpur, Bihar, an accident took place on 14-3-1991 at 12 noon in SH Section-3 wherein a worker named Sagar Sinku died on the spot. Factory Inspector Shri Shashibhushan investigated the accident and found that in an open railway wagon (gandola) when ingots were put, scrap was not removed and during movement the heavy scrap was falling and lying on the rail track. Before driving the loco-engine, instability of the heavy material was not checked. Rail-track was also not checked. Therefore while driving, the. wheels were jumped and the loose scrap including an 8 tonne article came out and fell on the worker who died. It was also found that the wagon shutters were not closed and instead of a trained driver, B-grade jamadar was driving the engine. Defence advocates told that the company is giving every thing for safety, accident happened due to human error and there is no fault of the company. The court observed that two witnesses - Sayeed Shaukat ali and Satyanarayan had put the article in the wagon, but the company failed in supervising that the article was put properly and safely or not. Court also criticized the driving by shunting jamadar. (Abstract from 'SalamatT, Vadodara, May-2000 issue).

7 ROLE OF THE ILO FOR SAFETY, HEALTH AND WELFARE

7.1 Introduction :

International Labour Organisation Was established in 1919 with its headquarters in Geneva. It has about 155 member countries and offices and experts in many countries. The opening words of its constitution 'Universal and lasting peace can be established only if it is based on is social justice' indicate its main object. The protection of the worker against 'sickness, disease and injury arising out of his employment' is also one of the essential tasks of the ILO.

Standard-setting is the ILO's oldest activity and it remains its fundamental task. Between 1919 and 2006, the ILO adopted 186 conventions and 195 recommendations. Out of these about 83 Conventions and 85 Recommendations relate directly or indirectly to safety, health and working environment. The ILO has published over 250 studies and publications dealing with safety and health.

It carries out technical co-operation, international supervision, ensuring effective application, labour inspection, occupational health services, meetings, symposia, activities in the field of ergonomics, expert consultancy service, employment injury statistics, vocational rehabilitation. International Occupational Safety and Health Hazard Alert System and International Occupational Safety and Health Information Centre (CIS) for regular ILO publication and computerised data etc. See Part 7.2.3 of Chapter6 for ILO activities.

The last Encyclopaedia of Occupational Health and Safety (Fourth revised edition in 1998) contains four volumes. These volumes are the best guide on many matters of health and safety.

Preparation of international standards for the protection of workers' health is its main aim. Such standards, in the form of Conventions and prevention, labour inspection, occupational health and diseases, maximum weight, electrical accidents etc.

Another major sector of ILO's work consists in the provision of expert advice and technical assistance in matters connected with labour and social policy. Assistance is provided under the United Nations programmes of technical cooperation as well as under the ILO's regular budget. Much of this operational work lies in the fields of manpower training and utilisation, improvement of work methods and organisation, labour administration and the development of effective systems of industrial relations and social security.

These activities are organised by the International Labour Office, and international staff in Geneva with a field network in most parts of the world. The Office is also the permanent secretariat of the Organisation and a clearing house for international information and research. It is headed by a Director General appointed by a Governing Body of 24 government representatives, 12 representatives of management and 12 representatives of labour, which meets three times a year.

In addition to the above activities, matters of concern to particular region and industries are discussed periodically by special conferences and committees. Many specialised technical meetings are organised. An International Institute of Labour Studies, set up by the Organisation at Geneva, provides persons occupying positions of responsibility in the different countries with opportunities for advance study of labour policy questions.

The main activities of the ILO in the field of safety, health and welfare can be broadly classified as under:

1. Conventions and Recommendations.
2. Standards and Codes of Practice.
3. Exchange of technical information & Research.
4. Technical co-operation activities.

They are explained in brief below :

7.2 Conventions and Recommendations:

Since its inception in 1919, the ILO has adopted over 300 international instruments - Conventions and Recommendations. A Convention is a legal document regulating some aspects of labour administration, social welfare or human rights. A Convention creates binding obligations by virtue of its ratification by the member- country concerned. A Recommendation is complementary to a Convention except-that it is not subject to ratification. The very first Convention of the ILO, adopted in 1919, was on working hours in industry, the one, adopted in 1990, is on chemical safety and one adapted in 1993 is on major Industrial Accidents. It reflects the current practices and

These international agreements (Conventions) and recommendations relate to basic rights of labour, employment and training, conditions of work, social security and protection at work and are the result of detailed discussion at the annual International Labour Conference, comprising four delegates (two representing Government, one representing management and one representing labour) from each member country, speaking and voting individually. The .Conventions and Recommendations are not automatically binding, but governments must submit them to their national legislatures. Reports from the different governments on their implementation are examined annually by the Conference and there is also machinery for examination of complaints, including alleged violation of freedom of association.

Though due to socio - economic conditions in the country and the prevailing situation it has not been possible for our country to ratify all of these Conventions. Most of the requirements are met to some extent in organised sectors of our industries such as some big factories, mines and docks.

Some ILO Conventions and Recommendation pertaining to Safety Health and Environment are give: in Table 27.5.

Table 27.5 : ILO Conventions & Recommendations

Subject	Convention No. and Year	Recommendation No. and Year.
Workmen's Compensation	12 (1921) 17, 18 19 (1925) 42, (1934)	22, 23, 24, 25 (1925)
Anthrax Prevention	-	3 (1919)
Lead Poisoning	-	4 (1919)
White Lead (Painting)	13 (1921)	
White phosphorous	-	6 (1919)
Medical Examination	16 (1921), 73, 77, 78 (1946), 113 (1959), 124 (1965)	79 (1946)
Medical Advice	-	106 (1958)
Sickness Insurance	25 (1927), 56 (1936)	29 (1927)
Protection of worker's health	-	97 (1953)
Marking of weight	27 (1929)	
Protection against Accidents	28 (1929), 32 (1932)	33, 34 (1929) 40 (1932)
Sheet Glass works	43 (1934)	
Underground work (women)	45 (1935)	
Safety Provisions (Buildings)	62 (1937) Construction 167 (1988)	53 to56 (1937) 175 (1988)
Labour Inspection	81 (1947) 129 (1969)	5 (1919), 20 (1923), 28 (1926), 81, 82 (1947), 133 (1969)
Labour Standards	83 (1947)	
Labour Inspectorates	85 (1947)	59 (1939)
Radiation protection	115 (1960)	114 (1960)
Power – driven machinery	-	32 (1929)
Guarding of machinery	119 (1963)	118 (1963)
Hygiene (Commerce & Officer)	120 (1964)	120 (1964)

Employment Injury Benefits	121 (1964)	121 (1964)
Maximum weight	127 (1967)	128 (1967)
Medical Care & sickness Benefits	130 (1969)	69 (1944), 76 (1946), 134 (1969)
Prevention of Accidents	134 (1970)	31 (1929), 142 (1970)
Benzene	136 (1971)	144 (1971)
Occupational Cancer	139 (1974)	147 (1974), 194 (2002) list of occupational diseases
Working Environment (Air pollution, Noise & Vibration)	148 (1977)	156 (1977)
Labour Administration	150 (1978)	158 (1978)
Occupational safety & Health	152 (1979), 155 (1981) 161 (1985)	112 (1959), 164 (1981), 160 (1979) 171 (1985)
Labour Statistics	160 (1985)	

ILO Conventions ratified by India are give in Table 27.6

Table. 27.6 : ILO Conventions Ratified by India

Sr. No.	No. and Title of Convention	Date of Registration of Ratification
1	No. 1 Hours of work (Industry) Convention 1991.	14-7-1921
2	No. 2 Unemployment Convention, 1919.	14-7-1921 denounced on 16-4-1938
3	No. 4 Night Work (Women) Convention, 1919	14-7-1921
4	No. 5 Minimum Age (Industry) Convention, 1919.	9-9-1955
5	No 6 Night Work of Young Persons (Industry) Convention 1919	14-7-1921
6	No. 11 Right of Association (Agriculture), Convention, 921	11-5-1923
7	No. 14 Weekly Rest (Industry) convention, 1921	11-5-1923
8	No. 15, Minimum Age (Trimmers and Stokers) Convention, 1921	20-11-1922
9	No. 16 Medical Examination of Young Persons (Sea) Convention 1921.	20-11-1922
10	No. 18 Workmen's Compensation (Occupational Diseases) Convention 1925	30-9-1927
11	No. 19 Equality of Treatment (Accident Compensation) Convention 1925.	30-9-1927
12	No. 21 Inspection of Emigrants Convention, 1926	14-1-1928
13	No. 22 Seamen's Articles of Agreement Convention, 1926	31-10-1932
14	No. 26 Minimum wage-fixing Machinery Convention, 1928	10-1-1955
15	No. 27 Marking of weight (Packages transported by vessels) Convention, 1929.	7-9-1931
16	No. 29, Forced labour convention, 1930	30-11-1954
17	No. 32 Protection against Accidents (Dockers) Convention (Revised) 1932.	10-2-1947
18	No. 41 Night work (Women) Convention (Revised)	22-11-1935 denounced on

	1934.	27-02-1950
19	No. 42, Workmen's Compensation (Occupational Diseases) Convention (revised), 1934.	13-1-1964
20	No. 45 Underground work (Women) convention. 1935	25-3-1938
21	No. 80 Final Articles Revision convention, 1946.	17-11-1947
22	No. 81, Labour Inspection Convention, 1947.	7-4-1949
23	No. 88, Employment service convention, 1948.	24-6-1959
24	No. 89, Night work (Women) Convention (Revised) 1948.	27-2-1950
25	No. 90 Night work of Young Persons (Industry) Convention (Revised), 1948.	27-2-1950
26	No. 100 Equal Remuneration Convention, 1951.	25-9-1958
27	No. 105, Abolition of Forced Labour Convention, 1957	18-5-2000
28	No. 107, Indigenous and Tribal populations Convention, 1957	2-9-1958
29	No. 108, Seafarers' Identify documents Convention 1958.	17-1-2005
30	No. 111, Discrimination (Employment and Occupation) Convention, 1958.	3-6-1960
31	No. 115, Radiation protection, Convention, 1960.	17-11-1975
32	No. 116, Final Articles Revision Convention, 1961.	21-6-1962
33	No. 118, Equality of Treatment (Social security) convention 1962.	19-8-1964
34	No. 122 employment of policy Convention, 1964	17-11-1998
35	No. 123, Minimum Age (Underground work) Convention, 1965.	20-3-1975
36	No. 136 Benzene Convention, 1971	11-6-1991
37	No. 141, Rural Workers Organisations Convention, 1975.	18-8-1977
38	No. 144, Tripartite Consultation (International) Labour Standards) Convention, 1976.	27-2-1978
39	No. 147, Merchant shipping (Mini. Std) Convention, 1976	26-9-1996
40	No. 160 Labour statistics convention, 1985	1-4-1992
41	Protocol of 1990 to Night Work (Women) Convention, (Revised0 1948	21-11-2003

Details of above conventions and recommendations are available on http:// www.ilo.org/ilolex/cgi-lex/convde.

A brief note of some conventions and recommendation is given below. For details the full text should be referred.

(1) Occupational Safety and Health (Conv. 155 and Recom. 164 of 1951) :

This convention was adopted on 22-6-1982 and includes -

1. Scope and Definition regarding branches of economic activity, workers, workplace, regulations and health.

2. Principles of National Policy concerning SHE to prevent accidents and injury. It should include safety of workplaces, working environment, tools, machinery, equipment, work processes and chemical, physical and biological agents, training, communication and cooperation, respective functions and responsibilities.

3. Action at the National level requiring formulation and enforcement of laws and regulations, guidance to employers and workers, functions of authorities, designers and manufacturers, imminent danger, education and training.

4. Action at the level of Undertaking regarding safety of workplaces, machinery, processes etc,-control measures including PP"E, emergency plans, obligations of workers, safety training, reporting of imminent danger and co-operation.

5. Final provisions requiring ratification, denunciation after 10 years etc.

Supplementing above convention, the Recommendation adopted on 22-6-1981 includes -

1. Scope and Definitions of branches of economic activity, workers, workplace, regulation and health.

2. Technical Fields of Action regarding priority to eliminate hazards at source, safe design, maintenance and means of access, lighting, ventilation, cleanliness, temperature, humidity, air movement, testing and inspection of machinery, prevention of harmful stress, material handling, use of electricity, safe use of dangerous substances, radiation protection, noise and vibration, ambient factors, fire and explosion, PPE, welfare facilities, first-aid, emergency plans and health supervision.

3. Action at the National level for policy and technical actions implementation, making codes of practice for safety & health, laws on safety & health, studies & research, information and advice to employers and workers to eliminate hazards, liaison with ILO, system of inspection and co-operation with public authorities.

4. Action at the level of Undertaking regarding safety of workplaces, machinery, equipment &: methods, instruction, training & supervision PPE, working hours, physical and mental fatigue, safety policy and committee, health and safety service, safety standards, records and workers' safety duties.

See Sec. 7A & 41 B of the Factories Act and Rules 68K to 68Q and certain schedules N/r 102, GFR.

(2) Occupational Health Services (Conv. 161 and Recom. 171 of 1985) :

This convention was adopted on 26-6-1985 and

1. Principles of National Policy.
2. Functions by Employers.
3. Organization of occupational health services
4. Conditions of operation and

5. General Provisions.

Here 'Occupational health services' means services entrusted with essentially preventive functions and responsible for advising the employer, the workers and their representatives in the undertaking for maintaining safe and healthy working environment and adaptation of. work not beyond the capabilities of

National policy is suggested on this matter. Employers' functions include risk assessment, welfare facilities, safe workplaces and practices, equipment, ergonomics, health surveillance, vocational rehabilitation, training, first aid, emergency treatment and analysis of occupational accidents and diseases.

Laws and regulations are expected on this aspect. Workers should be informed of their health hazards. Absence due to ill health is to be reported.

Supplementing the above convention, Recommendation was adopted on 26-6-1985 which includes –

1. Development of occupational health services for workers.
2. Preventive role of such health services.
3. Assessment of risks, PPE, monitoring methods and control systems to eliminate or reduce exposure.
4. Functions of occupational health services.
5. Surveillance of workers' health i.e. pre-employment, periodical and post employment medical examinations, detection of exposure levels, biological monitoring, reporting of absences due to health reasons, health records, fitness certificate etc.
6. Training programmes on health and hygiene.
7. Informing workers about their health hazards and health records.
8. First aid and emergency treatment for accidents, immunisation for biological hazards and medical aspects of vocational re-education and rehabilitation.
9. Common services to different undertakings permissible.
10. Standards for. premises and equipment can be prescribed.
11. Health services and safety services can be organised where appropriate.

See Sec. 41-C and Sch. 3 of the Factories Act and Rules 68R to 68 V of the GFR.

(3) Asbestos (Conv. 162 & Recom 172 of. 1986) :

This convention was adopted on 24-6-1986 and includes six parts as under -

1. Scope and Definitions.
2. General principles.
3. Protective and preventive measures.
4. Surveillance of working environment and workers' health.
5. Information and Education.
6. Final provisions.

Definitions of asbestos, asbestos dust, airborne asbestos dust, respirable asbestos fibres and exposure to asbestos are explained. National laws, their enforcement, system of inspection and responsibility of employers and workers are prescribed.

Protective measures include- engineering controls, workplace hygiene, substitution of harmless process, prohibition of crocidolite and spraying of asbestos, labelling of container, exposure limits, respiratory equipment, special protective clothing, demolition work by authorised persons, washing and bathing facility, safe disposal, preservation of record, medical examinations, notification of diseases, education and training.

Supplementing above Convention, Recommendation was adopted on 24-6-1986 which includes

1. Scope and definitions as in Convention.
2. Consideration of code of practice on safety in the use of asbestos published by ILO.
3. Consultation with safety committee or workers representative.
4. Programme to prevent and control workers' exposure. No of persons and duration of exposure should be minimum.
5. Segregation of workplaces and use of control equipment.
6. Supply and use of MSDS.
7. Control of TWA limits and. maintenance of ventilation systems, machinery and protective appliances. Safe cleaning of workplaces.
8. Supply of respiratory equipment, special protective clothing and work clothing at no cost to the workers.
9. Measurement and sampling of exposure levels, medical examinations and health records.
10. Information and education for employers, workers and others.

See Sch. 17 u/r 102, GFR.

(4) Safety in the use of Chemicals at work(Con.l70 and Rec.l77 of 1990)

The ILO Convection No.170 and Recommendation No-177 were adopted on 25-6-1990 for the purposes of:

1. Evaluating chemicals for their hazards.
2. Providing information of chemical hazards from suppliers to employers and to workers.
3. Establishing principles and co-operation to use chemicals safely.

The convection provides for classification systems, labelling and marking of chemicals to identify their hazards, material safety data sheets, responsibility of suppliers, employers and exporting states and duties and rights of workers. Employers' responsibilities include identification of chemicals, safe transfer of chemicals, control of exposure and operations, safe disposal and information, training and co-operation to workers.

The Recommendation applies in conjunction with the Convection and prescribes details of:

1. Criteria for classification of chemicals.
2. Labelling and marking.
3. Chemical safety data sheet.
4. Monitoring of exposure.
5. Operational control within the workplace.
6. Medical surveillance.
7. First aid and emergencies.
8. Co-operation amongst employers, workers and suppliers.
9. Rights of workers.

The criteria suggested for classification include:

1. Toxic properties including acute and chronic health effects, allergenic, sensitising, carcinogenic, teratogenic and mutagenic effects and effects on reproductive system.
2. Chemical and physical properties including flammable, explosive, oxidising and dangerously reactive properties.

Control measures are also suggested to assess, monitor and record chemical concentrations at workplace, to prevent occupational diseases, fire, explosion and other events, to select safe chemicals, processes, technology, engineering controls, working systems, practices, personal hygiene measures, suitable PPE, signs, notices and to make safe provisions for emergency preparedness, storages, labelling, loading/ unloading, transport, waste disposal, medical surveillance and first-aid arrangements.

See Sch. 19. u/r 102, GFR.

(5) Prevention of Major Industrial Accidents (Con, 174 & Recom. 181 of 1993)

This convention was adopted on 22-6-1993 and provides following parts

1. Scope and Definitions.
2. General principles.
3. Responsibilities of Employers - Identification, Notification of installation. Arrangements of installation. Safety report and Accident reporting.
4. Responsibilities of Authorities - Offsite emergency plan. Sitting of MAJH installations and Inspecting staff for them.
5. Rights and Duties of workers and their representatives.
6. Responsibility of Exporting States and
7. Final provisions.

Supplementing above convention, Recommendation was also adopted on the same day which provides for exchange of information with ILO on safety management, process safety, major accidents, lessons from near misses, technical and medical control measures and systems to compensate workers.

See MSIHC Rules 1989 and Rule 68J of GFR incorporating intention and details' of above Convention and Recommendation. See Chapter 28 for such laws.

Each MAH installation employing == 100 workers is required to employ one Safety Officer in Gujarat vide notification dated 28-5-2004 of the Labour and Employment Dept, Sachivalaya, Gandhinagar.

7.3 Standards and Codes of Practice :

Another form of ILO standards are the Model Codes of Regulations. Amongst these is the Model of Regulations for Industrial Establishments for the guidance of governments, applicable to the majority of industrial undertakings and covering all matters concerning occupational hygiene, welfare and health.

Further guidance is provided in codes of practice to be used as reference work by any one in charge of formulating detailed regulations or responsible for the occupational safety and health. More than 20 codes of practice have been drawn up so far, covering either different sectors of activity (such as a mines, agriculture, forestry, construction and public works, ship building and repairing, iron and steel), or particular risks (Ionising radiation, noise and vibration, exposure to airborne harmful substances).

Codes of practice indicate "What should be done, they are. prepared by meetings of experts and their publication is approved by the ILO Governing Body.

These codes are further being supplemented by Guides .or Manuals often taking the form of illustrated texts showing practical ways of solving various problems at plant or work level; e.g. Dust prevention in Mining, Tunnelling and Quarrying; Guide for Labour Inspectors; Accidents prevention (A Workers' Education Manual), Guide on Forestry Work; Guide on Safety in Agricultural Work and a series of manuals on Industrial Radiation Protection, ranging from the relevant Convection (No. 115) to the Mining and Milling of Radioactive ores.

It is fair to say that ILO standards have exerted considerable influence on the laws and regulations of member country. Many texts have been modelled on the relevant provisions of ILO instruments; drafts of new legislation or amendments are often prepared with ILO standards in mind so as to ensure compliance with ratified Conventions or to permit the ratification of other Conventions; trade unions use ILO standards to support arguments in bargaining and in promoting legislation; Governments frequently consult the ILO both formally and informally, about the compatibility of proposed texts with international labour standards.

The ILO has prepared a "Code of Practice of Major Hazard Control", The Code of Practice is written in legislative style so that it can be a model for national legislation in this field.

7.4 Exchange of Technical Information and Research

This activity covers the issue of various publications such as studies, reports on enquiries, monographs, collection of laws, manuals, guides, etc. Thus during the last ten years, the ILO has published over 160 different studies and other publications dealing with occupational safety and health.

The subject-matters dealt with in some more recent publications include, in addition to the manuals and guides already mentioned: report on the maximum weight carried by one worker, the medical inspection of labour, electrical accidents, and related matters. The ILO also publish, at fixed intervals, directories on occupational safety and health services and institutions on safety courses and a catalogue of safety and health films produced the world over.

Together with a number of international and regional organisations and some 30 odd national centres, the "ILO set up in 1960 the International Occupational Safety and Health Information Centre(CIS). The essential aim of the Centre is to make information available rapidly and systematically to interested quarters on all aspects of occupational safety and health in every type of industrial activity. The information is printed on cards and in a bulletin despatched every four weeks to subscribers. The centre is supplied with information by national centres in additions to that submitted directly by the authors or editors of books, studies or articles. Another type of publications by the office are those in the "Occupational Safety and Health" series of which over 30 have so far been produced, starting in 1963. They aim at disseminating technical information among those interested in the ILO's work on the conclusions adopted by technical meetings or panels of experts.

An encyclopaedia on occupational safety and health, mentioned earlier, is intended for a vast readership and should be of interest to all concerned, both in the public as well as in the private sectors who are directly or indirectly responsible for the worker's safety and health, as well as to those who are concerned with these problems in any other context and who sometimes find it difficult to have access to the information required by them since this is often either too specialised or hard to obtain:

7.5 Technical Co-operation Activities :

The main forms of such technical assistance is the assignment of experts to evaluate conditions of safety and health obtaining in a given country and advising Government and Industry on the best means and ways of developing and strengthening the measures aimed at preventing accidents and occupational diseases and improving the conditions of work; this is very often accompanied by the assistance in the preparation of revision of the pertinent legislation and administrative procedures in this field. In many cases, technical equipment, often of the most advanced and sophisticated type, is being provided for the laboratory, demonstration and teaching purposes together with expert advice on their use. The ILO grants fellowships for studies/training in Safety and Health techniques as well as in conducting seminars and training centres in the countries, mostly on a regional basis. Local efforts for the organisation of activities are also being suggested and furthered by the office.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1 Stages of Development of safety movement in the. world.
2 History of factory legislation in India.
3 Development and provisions of the Factories Act 1891 or that of 1911.
4 Provisions of the Factories (Amendment) Act 1976 or 1987.
5 Main safety provisions of the Factories Act 1948 .as on today.
6 Provisions pertaining to the hazardous processes under the Factories Act, 1948.
7 'Shriram' food and fertilizer's case by Supreme court's judgment.
8 Role of ILO for Safely, Health & Welfare.
9 Any one ILO Convention on Safety or Health in detail.
10 Safety provisions of any one machine u/r 54 of the Gujarat Factories Rules, 1963.
11 Safety provisions of any one Dangerous operation u/r 102 of the GFR.
12 Provisions of medical requirements under the Factories Act and GFR as on today.
13 Fire Safety provisions under GFR.
14 Provisions of 'Chemical works' under GFR or of 'Benzene' manufacture.
15 Provisions regarding ‘competent person’.
16 Safe working with pesticides.
17 Safety Provisions for ''pottery' or 'foundry'.
18 Provisions regarding ventilation and Temperature.

2. Write Short Notes on :

1 Earlier views of US courts on labour laws.
2 History of Labor legislation in England.
3 The first Factories Act 1881.
4 The Factories Act 1922.
5 Major Provisions of the Gujarat Factories (Amendment) Rules, 1995.
6 Health provisions or welfare provisions under the Factories act as on today.
7 SC judgment on 'Asbestosis' or on 'Occupier'.
8 ILO conventions.
9 Safety aspects of Hoists & Lifts.
10 Fencing of machinery.
11 Protection of eyes.
12 Thermic Fluid Heater or Ovens & Driers.
13 Reaction Vessel and Kettle.
14 Working on fragile roof.
15 Revolving machinery.
16 Safety provisions to work in explosive or toxic atmosphere.

17 Ambulance room.
18 Constitution and working of safety committee.
19 Safety provisions for pressure vessels or lifting machines.
20 Provisions u/s 41-B of the Factories Act.

3. Explain the Difference between :

1 Provisions of Chapter 4 and 4A of the Factories Act 1948.
2 Convention, Recommendation and Ratification of ILO.
3 Hoist and Lift.
4 Working at height and working in confined space under the provisions of the Factories Act.
5 Fixed guard and interlock guard with example.
6 Onsite and offsite emergency plan.
7 Safety policy and safety committee.
8 TLV and STEL value with example.
9 Accident and dangerous occurrence.
10 'Director' in public limited company and the Government company.
11 Duties of 'Safety officer' and 'Welfare officer'.
12 Hazardous process and manufacturing process.
13 Machinery and transmission machinery.
14 Lifting machine and lifting tackle.

4. Comment on following explaining whether it is True or False?

1 Oldest need of labor laws was felt necessary for children and women and not for adult men for safety.
2 Earlier laws were in favour of employers and not in favour of employees.
3 Offences under the Factories Act do not attract absolute criminal liability.
4 Interpertain of the Factories Act should be liberal and beneficial in favour of workers but strict in favour of occupiers.
5 Height of transmission machinery above 15 ft was considered safe by position.
6 Guard should be provided only when Factory Inspector suggests it.
7 If someone removes the guard, it can be pleaded as valid defence by the occupier.
8 'Manufacturer did not provided a guard and therefore it was not there' can be a defense by the accused'.
9 Ignorance of law can be pleaded as defense.
10 Uncovered pit has inherent danger.
11 Compliance with safety measurers is not mandatory.
12 Contractors' workers are not the. workers under the Factories Act 1948.
13 Judge can inflict any fine, even less than minimum prescribed.
14 Not providing identify cards to workers is not a serious offence.
15 Where canteen is provided, lunch room is not necessary.
16 Two-hand control is not useful while working on power-press.
17 When there are two safety valves on a pressure vessel, their set pressure difference should be more than 10%.
18 Breathing space required by each worker in a work room should at least 16.2 cu.mts.
19 Power includes all types of energy including animal energy.
20 'Acid' under Sch-12 includes chlorosulphonic acid also.

Reference and Recommended Reading

1. The Factories & Labour Manual by R. Mathrubutham & R Srinivasan, The Madras Law Journal Office, Madras.
2. Commentaries on the Factories Act 1948, K.D. o Srivastava, Eastern Book Co., Lucknow - 1.
3. Factory Laws in Gujarat, K.L. Sethi, United Law Publishers ltwara, Indore.
4. Factory Law in Gujarat M.L. Jindal, India Publishing House, HC Road, Jodhpur-1.
5. Factories Act, Sethi R.B. & Dwivedi R.N. Law Book Co. Allahabad-1
6. The Industrial Law, P.L. Malik, Eastern Book Co. Lucknow-1.
7. Digest of Factory Law Cases under the Factories Act, 1948.
8. Labour Law Journal Digest.
9. Encyclopaedia of Occupational Health & Safety, ILO, Geneva.
10. Synopsis of the Gujarat Factories (Amendment) Rules, 1995, by K.U. Mistry, Siddharth Prakashan, Ahmedabad.
11. International labour Conventions and Recommendations, 1919-1994 - TT.O

Note : The Content mentioned in this Chapter must be updated with the amended law for the purpose of Examination or Applicability.

CHAPTER – 28

Specific Safety Laws

THEME

Only an abstract (short summary) of some Acts and Rules is given below. For frill details the statute books must be referred, for the factories Act and Rules Chapter-27 should be referred.

1. LAWS ON BOILER SAFETY :

1.1 Boilers Act, 1923:

The Boilers Act (No. 5 of 1923) was notified on 4-12-1923. It came into force from 1-1-1924. It has 34 sections. It is amended by the Act No. 49 of 2007 which became effective by Notification dtd. 13-12-2007. Section 2 of the Act defines as under :

Boiler means a pressure vessel in which steam is generated for use external to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel-

(i) with capacity. < 25 ltrs (such capacity being measured from the feed check valve to ,the main steam stop valve)
(ii) with < I kg/cm' design gauge pressure and working gauge pressure or
(iii) in which water is heated below 100 °C.

Boiler Component means steam piping, feed piping, economiser, super heater, any mounting or other fitting and any other external or internal part of a boiler which is subject to pressure exceeding I kg/ cm2 gauge.

Economiser means any part of a feed-pipe that is wholly or partially exposed to the action of flue gas for the purpose of recovery of waste heat.

Super heater means any equipment which is partly or wholley exposed to flue gases for the purpose of raising the temperature of a steam beyond the saturation temperature at the pressure and includes a reheater.

Steam Pipe : means any pipe through which stream passes if (i) The pressure at which steam passes through such pipe exceeds 3.5 kg/ m2 above atmospheric pressure or (ii) Such. pipe exceeds 254 mm in internal diameter and pressure > I kg/cm2 and includes, in either case any connected fitting of a steam pipe.

Accident as defined u/s 2(a) means an explosion of boiler or boiler component which is calculated to weaken the strength or an uncontrolled release of water or steam therefrom, liable to cause death or injury to any person or damage to any property.

Sec. 18 requires report of accident and inquiry in case of fatal accident.

New definitions of Competent authority, Competent person. Inspecting authority. Technical advisor and structural alteration, addition or renewal are added.

Now not only boiler inspector but competent person can also inspect and certify boiler and its components during manufacture, erection and use. Inspecting authority can do this job during manufacture.

Unregistered or uncertified boiler shall not be used save as otherwise provided in the Act. Prior sanction of the Chief Inspector is necessary before carrying out any structural alteration, addition or renewal in or to any boiler or steam pipe. Any accident to a boiler or steam pipe shall be reported to the Inspector within 24 hours. His report shall be in form E (Rule 48).

Section 27A provides to form a Central Boiler Board consisting of members, nominating by the Central Government the representatives from the Central Government, Bureau of Indian Standards, Boiler and boilar component manufacturers. Users and other interests.

Section 28 provides power and matters of regulations by the Board. Sec. 28Aand 29 are for the rule making power of Central and State Govt. respectively.

Central Boilers Board makes and notifies regulations consistent with this Act. The main duties of the Boiler Inspector are the inspection and examination of boilers and steam-pipes in accordance with chapter IX of the Regulations and Chapter IV and V of the Gujarat Boiler Rules 1966. Reduction of pressure can be suggested. Sanction for repairs to boilers shall be obtained beforehand. Provisional orders should be issued after hydraulic tests.

Penalties have been increased up to Rs. 1 lac or /and 2 years imprionment u/s 24.

1.2 Gujarat Boiler Rules, 1966

These rules were notified and came into force on 20-10-1966. They have 162 rules, of which R.73 to 136 repealed, and Forms A to D.

The Chief Inspector shall issue instructions to owners for safe working of boilers. Form C under rule 8 provides such instructions regarding precautions before starting the fires, raising steam, pressure gauge, steam pressure, safety valve, low water safety valve, water gauges, blow-off cock, scum cock, manhole and other door joints, steam pipes, scale and grease, wear and tear, scale removal. Treatment of feed water and preservation of boilers when not in use. These instructions (Form C) are most important and should be hung up in each boiler house. For safety purpose it must be thoroughly understood and followed.

It should be the first care of the Boiler Owner and the Boiler Attendant to see that the feed water is kept as pure as possible. Impure feed water means additional expense on the upkeep of the boiler.

Steam boilers when not in use are liable to deterioration from corrosion and unless well cared for and made rust-proof, they may depreciate more rapidly than when in use. They should be thoroughly drained" and thoroughly dried and all valves, cocks and openings closed so as to exclude moisture. Another plan is to fill the boiler with water to which about 1/100 per cent, caustic soda has been added.

1.3 Gujarat Boiler Attendant Rules, 1966:

These rules were notified on 23-12-1966. They have 56 rules and Forms A to G.

Boiler shall be in charge of a qualified boiler attendant. Rules for examinations to grant certificate of competency as a Boiler Attendant are also prescribed. Age limit for second class Boiler Attendant is 20 years and that for first class Boiler Attendant is 21 years. For second class Attendant, 3 years relevant experience or training are necessary. For first class Attendant, 2 years service as second class Attendant on a boiler of more than 46 m~ heating surface is necessary.

1.4 Indian Boilers Regulations, 1950 (IBR) :

The Central Boilers Board u/s 28 of the Boilers Act, 1923 published the Indian Boiler Regulations 1950. They came into force from 15-9-1950. They were amended in 1990, 1993, 1994, 1995, 1996, 1997 and 2004. They have 15 chapters, 635 regulations, forms up to XVIG and Appendices A to M.

Definitions:

Definitions of accident, boiler. Chief Inspector, economiser, feed-pipe and owner are the same as given in the Act.

Competent Authority means an authority recognised by the Central Boilers Board to issue certificates to welders for the purposes of regulation 4(b)(ii) and 605.

Inspecting Authority means an authority recognised by the Board as competent to grant a certificate in Form II, IIA or IIB and specified in Appendix-C, which includes Chief Inspectors of boilers of various states of our country as well as foreign and many foreign companies.

Inspecting Officer means an officer appointed by the Inspecting authority or an officer acting on their behalf for the purposes of approval of drawings, stage wise inspection of manufacture, examination of repairs, signing and issue of certificates, material manufactured and boilers constructed.

Thus the central boilers board and authorities and officers recognised by them provide the backbone of boilers safety and checking from design to operation, maintenance and repair stages.

Boilers are classified as under :

Class	Limits of application	Minimum thickness	Constant
I	No limit	0.25 Inch	32
II	(a) WP < 105 psi (b) WP in psi x ID < 5250 inches.	IF ID is upto 36” 5/16 inch	27
III	(a) WP < 30 psi (b) WP in psi x ID < 3000 inches.	ID over 36”, 3/8 inch	23 if stress relieved 21 if stress not relieved

Working pressure (WP) of the cylindrical shell

$$WP(psi) = \frac{(t-2)SC}{D}$$

Where t = Min. plate thickness in 30 seconds of an inch.
D = Max. ID in inches.
S = Min. tensile strength in T/in'
C = Constant as given in above table

In no case, the thickness should be less than that mentioned in above table or the factor of safely less than 4.

Form -6 is the certificate for use of a boiler (reg. 389) with conditions. Appendix-J gives a long list of stages for inspection and testing by the Inspecting Authority. Appendix L provides for testing procedure for safety valve discharge efficiency.

Regulation 396 is regarding safety of persons inside boilers. Effective disconnection from steam or hot water, discharge arrangement for leakage, hand lamp of < 24 volt with lamp guard, key less socket, insulated handle and extension cord' of approved type are required. Power driven equipment should have effective earthing. Method of disconnection should be got approved from the CIB.

Chapter XIV (Reg. 618 to 622) was substituted with effect from 9-10-1993 and renamed as 'Small Industrial Boilers' (SIB).

Shell type SIB should have volumetric capacity > 22.75 ltrs. but < 500 ltrs, pressure up to 7 kg/cm2 or coil type or water tube boiler with capacity < 150 ltrs., pressure < 12 kg/cm2 Guidelines for registration, operation and maintenance are given in Reg. 622. Relaxations are given.

2. LAWS ON ELECTRICAL SAFETY:

2.1 Electricity Act, 2003 :

Replacing the Indian Electricity Act 1910, this Electricity Act 2003 (No. 36 of 2003) came into force on 10-6-2003. It was amended in the same year with effect from 21-1-2004.

It has 18 parts, 185 sections and a Schedule.

Its preamble runs as under :

An Act to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally of taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalisation of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, constitution :)f Central Electricity Authority, Regulatory Commissions and establishment of Appellate Tribunal and for matters connected therewith or incidental thereto.

Section-2 gives 77 definitions like board, captive generating plant, cogeneration, conservation, dedicated transmission lines, distribution system, electric line, electricity, electricity system, generating station, grid, high voltage line, line, main, overhead line, power system, service-line, street, sub-station, transmission lines and works etc.

Sections 3 toll are pertaining to grant of license and its revocation, amendment, purchase etc.

Section 161 regarding Notice of Accidents & Inquiries provides that (1) an accident to any person or animal resulting or likely to result in death or any injury is to be reported to the Electrical Inspector and other authorities in a prescribed time and (2) inquiry and report by the Electrical Inspector into the cause of accident affecting safety of the public and manner of compliance of statutory requirements.

Section 162 is regarding appointment of Chief Electrical Inspector and Electrical Inspector.

Subjects of this Act are asunder :

Part No.	Sections	Subject
1	1-2	Preliminary
2	3-6	National Electricity Policy and Plan
3	7-11	Generation of Electricity
4	12-24	Licensing
5	25-41	Transmission of Electricity
6	42-60	Distribution of Electricity
7	61-66	Tariff
8	67-69	Works
9	70-75	Central Electricity Authority

10	76-109	Regulatory Commissions
11	110-125	Appellate Tribunal for Electricity
12	126-130	Investigation and Enforcement
13	131-134	Reorganisation of Board
14	135-152	Offences and Penalties
15	153-157	Special Courts
16	158	Dispute Resolution
17	159-165	Other Provisions
18	166-185	Miscellaneous

2.2 Indian Electricity Rules, 1956 :

U/s37 of the Electricity Act, 1910, the Central Electricity Board, made these rules which were published and came into force from 26-6-1956.

The rules were amended in 1991, 1993, 2000, 2002. It has II Chapters, 143 rules and 15 Annexure. From safety point of view following two chapters are more important.

Chapter	Rules	Title
IV	29-46	General Safety Requirements.
X	109-132	Additional Precautions to be adopted in Mines & Oil-fields.

A short summary of the rules is given below. For full details, the statute book should be referred.

Rule 2 gives 57 definitions. 'Danger' is defined as danger to life or body part from shock, burn, fire, explosion, injury to persons or property because of the electrical energy.

Flameproof enclosure means an enclosure for electrical machinery or apparatus to withstand internal explosion due to flammable gas or vapour entered inside and preventing this internal flammation to come out to the external flammable gas or vapour in which it is designed to be used.

Guarded means covered, shielded, fenced or otherwise protected by means of suitable casing, barrier, rails or metal screens to remove the possibility of dangerous contact or approach by persons or objects to a point of danger.

'Intrinsically safe' as applied to apparatus or associated circuits shall denote that any sparking that may occur in normal working is incapable to cause explosion of inflammable gas or vapour.

Voltage category is defined as low<250V, medium<650V, high<33KV, extra high> 33KV.

Rule 4 prescribes appointment and qualifications for Electrical Inspectors that degree in electrical engineering with at least 8 years practical experience. For assistant inspectors BE(E) + 3 years experience or DME + 6 years experience is prescribed. Rule 5 gives their powers of entry and inspection.

Chapter-3, rules II to 28 prescribes licensing procedure including maps, forms and conditions.

Chapter-4, rules 29 to 46, give following general safety provisions:

General Safety Provisions:

1. Electric supply lines and apparatus, shall be of sufficient ratings, mechanical strength and so constructed, installed, protected, worked and maintained to ensure safety of human being, animals and property. IS and National Electrical Code shall be followed (R.29).
2. Supplier and consumer, both, will take due precautions to avoid danger from service lines and apparatus on consumer's premises (R.30).
3. Suitable cut-outs (e.g. fuse) in fireproof receptacles shall be provided in every service line (other than earth lines) at consumer's premises (R.31).
4. Earth and neutral conductors shall be identified to distinguish from live conductor and position of switches and cut-out shall be safe (R.32).
5. Earth connection (terminal) shall be provided near the point of start of supply and the consumer shall take steps to protect it from mechanical damage (R.33).
6. Bare conductors should be inaccessible with readily accessible switches to cut off power supply (R.34).
7. Danger notice in Hindi, English or local language with a sign of skull and bones (IS-2551) and the words 'danger and 'volts' is necessary near medium and higher voltage installation (i.e. above 250V). (R.35).
8. For the safety from supply lines and apparatus, earthing of lines, PPE to workers (gloves, rubber shoes, safety belts, ladders, earthing devices, helmets, line testers and hand lamps, for protection from electrical and mechanical injury), and authorised working on live lines are necessary (R.36).
9. Voltage cut off switch (in one operation) is a must in every electric vehicle, crane, etc. and the metal rails, if any, should be electrically continuous and earthed (R.37).
10. Flexible cables to portable apparatus should be heavily insulated and well protected from mechanical damage. For single phase line the cable should be of 3 core and for 3 phase line, it should be of 4 core type with the distinguished ground connection. Metal covering, if any, should be earthed (R.38).
11. Insulating or protecting material of electric line should not be of such material that may produce noxious or flammable gases on excessive heating (R.39).
12. Street boxes should be free from influx of water or gas. They should be inspected regularly for that (R.40).
13. Different circuits should be distinguished from each other (R.41).
14. Voltage should not exceed the limits and AC-DC circuits should not come into contact with each other when live (R.42).
15. Fire extinguishers for electric fire, fire buckets with clean, dry sand, first-aid boxes, two or more gas masks to be used in the event of fire or smoke are necessary (R.43).
16. Notice of instructions to restore person from electric shock and an artificial respirator (resuscitation) necessary (R.44).
17. Fatal accident should be reported within 24 hours and non-fatal accident, in Annex-XIH, in 48 hours (R.44A).
18. Electric work shall be carried out by licensed electrical contractor under direct supervision of a competent person and a person holding permit by the State Government. Unauthorised work shall not be energised (R.45).
19. Inspection of installation at every 5 years by the Inspector. Annex-IXA is an inspection report Form (R.46).

Chapter-V (R.47 to 59) gives general conditions relating to supply and use of energy. Rule 51 for medium, high and extra high voltage installations should be referred. .

Chapter-VI (R.60 to 62) for low and medium voltages (upto 650V) and Chapter-VU (R.63 to 73) for high and extra high voltage (more than 650V) provide for insulation resistance test, earth connection, ELCB, testing, operation and maintenance, condensers and supply to high voltage installation including X-ray unit, etc.

Chapter-VIII (R.74 to 93) gives important safety clearances (see Part 4.6 of Chapter-11) above ground and between conductors and provisions for material strength, stresses, joints, guarding, earthing, safety and protective devices (R.91 for safety of line when it breaks, unauthorised entry near overhead lines) etc.

Chapter-IX (R.94 to 108) is for electric traction, and provides for voltage supply to vehicle, insulation of lines, returns and sections, current density (less than 1.4 Amp/cm2) in rails, height of trolley-wire (more than 5.2 m high) etc.

Chapter-X (R.109 to 132) is regarding safety precautions while working in mines and oil-fields. They include plans, notices, lighting, communications, fire precautions, earthing, protective equipment, voltage limits (Hand lamp or electric interlocking 30V, portable apparatus 125V, at surface or in open 250V), safety with gas supervision etc.

Chapter-XI (R.133 to 143) gives relaxation and penalty provisions.

2.3 Electricity Rules, 2005

U/s 176 of the Electricity Act, 2003 these rules were made and they came into force from 8-6-2005. They were amended in the same year with effect from 26-10-2006.

They have 13 rules. Rule 3 gives requirements of captive generating plant. Other provisions are regarding distribution system, surcharge u/s 38, consumer redressal forum, tariff u/s 79, inter state trading licence etc.

3. LAWS ON FIRE AND EXPLOSION SAFETY :

3.1 Petroleum Act, 1934 :

This Act (No. 30 of 1934) came into force from 303-1937 (enacted on 16-9-1934) to consolidate and amend the law relating to import, transport, storage, production, refining and blending of petroleum. It extends to the whole of India. It has 4 chapters and 31 sections. Its abstract is as under :

Definitions :

Petroleum means any liquid hydrocarbon or mixture of hydrocarbons and any inflammable mixture (liquid, viscous or solid) containing any liquid hydrocarbon.

Flashpoint of petroleum means the lowest temperature at which it yields a vapour which will give a momentary flash when ignited, determined in accordance with chapter - II and rules made there under:

Petroleum class	F.P. Range
A	<23°C
B	23 to < 65°C
C	65 to < 93°C

Motor Conveyance means any vehicle running on land, water or air and in which petroleum is used to generate the motive power.

Control over Petroleum (Chap. 1, Sec. 3 to 13) :

The Central Government may make rules for import, transport, production, refining and blending of petroleum (Sec. 3 to 5).

On receptacles of class A petroleum the words "Petrol" or "Motor Spirit" should be mentioned. This is not required where quantity is less than 10 litres or on a fuel tank attached with a motor conveyance or engine, a pipeline, underground tank or exempted by the Central Government (S. 6).

Licence is not required (i) for class B petroleum if it is contained in a receptacle having less than 1000 litres capacity and total quantity at any one place does not exceed 2500 litres or (ii) for class C petroleum if total quantity at any one place does not exceed 45000 litres and stored or transported as per rules u/s 4 (S. 7).-

No licence is necessary to keep less than 30 litres class A petroleum not intended for sale. Then it can be stored in metal container of maximum 25 litres capacity and non-metal container of maximum I ltr capacity (S. 8).

To use as a fuel in a motor conveyance, not more than 100 litres class A petroleum can be stored or conveyed (S. 9).

No licence is needed by Railway to carry petroleum (R.IO). This chapter is not applicable to any petroleum having flash point above 93°C (S. II).

Testing of Petroleum (Chap. II Sec. 14 to 22) :

The Central Government can make rules for taking samples for testing and authorise any officer for that purpose (S. 14 to 17) to give certificate of testing (S.19) or retesting (S. 20). The officer shall use a standard test apparatus (S.15, 16 & 18). The Central Government has rule making powers u/s 21 and 22.

Penalties & Procedure (Chapter III S. 23 to 28):

General penalty is up to Rs. 1000 or one month or both and enhanced (for repeated offence) penalty up to Rs. 5000 or 3 months or both (S. 23). Petroleum together with receptacles can be confiscated (S. 24). Authorised officer has power of entry and search (S.26) Notice of accident shall be given to the nearest magistrate, police station and to the Chief Controller of Explosives (S. 27). In case of death or serious accident, inquiry u/s 176 of the Cr. P. C., 1973 shall be held by a Magistrate or a Police Commissioner.

Supplemental (Chapter -IV S. 29 to 31):

Rule making power and procedure and inclusion of rules to provide for protection of public from danger of petroleum (S. 29). The Central Government can limit or restrict the powers of any local authority (S. 31).

3.2 Petroleum Rules, 2002 :

These rules were enacted u/s 29 of the Petroleum Act, 1934. They came into force on 13-3-2002. They have 12 chapters, 202 rules, 5 Schedules and 20 Forms under the 2nd Schedule. Its abstract is give below:

Chapter -I : Preliminary (R. I to 13) :

Definitions:

There are 35 definitions. Some are given below.

'Adequate' in relation to ventilation, means the flammable gas-air mixture below the lower explosive or inflammable limit (LEL) or in relation to fire fighting facilities, those as per prevalent recognised standards or codes of safety.

Competent person means a person recognised by the Chief Controller of Explosives (CCE) or by an institution recognised by the CCE.

Container means a receptacle for petroleum of less than 1000 ltr. capacity.

Tank means a receptacle for petroleum of more than 1000 ltr. capacity.

Electric apparatus includes motors, starters, lamps, switches, junction boxes, fuses, cut-outs or any other appliance, equipment or fitting which operates electricity.

Hot work means any work which involves welding, burning, soldering, brazing, blasting, chipping by spark producing tools, use of certain power driven tools, non-flameproof electrical equipment or equipment with internal combustion engines and including any other work which is likely to produce sufficient heat capable of igniting inflammable gases.

Protected area means the safety distance 'specified by the licence condition under these rules.

Protected Works include dwelling house, assemble, dock, fuel yard, furnace, kiln, chimney, petroleum storage, public road, railway siding for oil and overhead high tension power lines.

Inspector, Sampling officer and Testing officer are those authorised u/s 13, 14 and 17 respectively.

There are many other definitions also like installation, OISD, petroleum inbulk, service station, storage shed and some vehicles with tank (R.2).

General Provisions (R 3 to 13):

Delivery and despatch not possible without storage licence. Class B petroleum up to 15000 litres in air tight approved container can be despatched to a person not holding a storage licence for immediate disposal. DCP extinguisher should be carried with a container of more than 2500 litres. Rule not applicable for despatch to the Defence Forces (R.3). Approval of CC is necessary for class A petroleum container of more than 1 litre capacity and class B & C petroleum container of more than 5 litre capacity (R.4). Containers for Class A petroleum should be of sound material an construction, approved type and of the following minimum thickness of iron or steel sheet –

Container Capacity in litres, exclusive of 5% free Space	Minimum thickness in mm
Up to 10	0.443 (27 BG)
Exceeding 10 and up to 25	0.63 (24 BG)

Exceeding 25 and up to 50	0.80 (22 BG)
Exceeding 50 and up to 200	1.25 (18 BG)
Exceeding 200 and up to 300	1.59 (16 BG)

The capacity of any container (Class A) shall not exceed 300 litres. Higher capacities for specified purposes need approval by CC. 5% air space necessary (R.5).

Minimum 5% and 3% air space are necessary for class B and C petroleum respectively (R.6).

Empty receptacles of class A or B petroleum should be kept securely closed if they contain vapour inside (R. 7).

Repair or hot work should be carried out after full cleaning of petroleum and its vapour or after certified by a competent person (R. 8).

Escape of petroleum to be prevented (R. 9). No person below the age of 18 or intoxicated shall be employed (R. 10). Smoking, fires, lights, matches etc. prohibited (R. II). No person shall commit or allow other to commit any act which may lead to any accident by fire or explosion. Compliance of these rules necessary. (R. 12). Fees (R. 13).

Chapter -II : Importation of Petroleum (R. 14 to 27):

Import licence necessary save as otherwise exempted. Rules for importation by sea requires fire fighting facilities as per OISD Std. .156, plans of unloading facility, protected works within 500 mt, EIA and Risk Analysis Report, failure scenarios, LEL distances, damage distances, control measures, anchorage of ships, production of certificate and licence to the Collector of Customs, no landing without his permission, of barges or lighters and transhipment from one ship to another (R. 14 to 24.).

Rules by importation by land also specify fixed places, submission of declaration (Form-1) certificate of storage accommodation (Form-H) and the licence to the Collector of Customs and no unloading without his permission (R. 25 to 27).

Chapter - III : Transport of Petroleum (R.28 to 101) :

Part - I : General (R.28 to 32):

No leaky tank or container containing petroleum shall be tendered for transport (R. 28). Filled containers should be kept upward (R. 29). Petroleum in bulk should riot be carried with passengers or combustible cargo (R. 30). Smoking, matches, lighters etc. prohibited (R. 31). Loading or unloading should not be done between the hours of sunset and sunrise unless adequate lighting and FFE are kept ready .(R. 32).

Part - II : Transport by Water (R. 33 to 50) :

Licence from the licensing authority is necessary (R. 33). Vessel should be made of iron or steel and of ample dimension (R. 34). All tanks on ships should be fitted with manholes with screw cover, air tight joints, filling and suction pipes and valves nearby to the bottom and filling and discharge through pipes and valves only. For class A petroleum,. Tanks should have vent or relief valve with wire mesh (more than II meshes per linear centimetre) and similar ventilators to all spaces around tank (R.35). Other provisions include exhaust outlet with spark arrester, no petrol driven engine, quick action closing valve on fuel feed pipe, suitable ventilators four or more fire extinguishers, 0.20 I113 of dry sand, non-sparking hammer, red flag, life-boats, ventilation and cleaning of holds and tanks, responsibility of master of vessel, loading/unloading through armoured hose and metal pipes electrically continuous and free from leakage, prohibition of naked lights, fire, and smoking, FFE in ready condition, no conveyance of petroleum class A with class B or C and no transport of un-tested petroleum (R. 36 to 50).

Part-111 : Coastwise Transport of Class A Petroleum not in bulk:

Rules 51 to 61 provide conditions and precautions for such transport.

Part-IV: Transport on Land by Vehicles (R. 62 to 86):

Applicable to transport of petroleum class A in more than 100 ltr (R. 62). Tank vehicles should be built, tested and maintained as provisions in 3rd schedule and of the type approved by the CC. Special safety fittings should be got approved (R.63). Class A and B petroleum can be filled up to 97% and Class C petroleum up to 98% of the gross carrying tank capacity (R.64). Tank vehicle should not be used for other purpose or carry other articles except authorised by the CC (R.65, 69). Trailers (R.66). For every mechanically propelled vehicle used to carry petroleum otherwise than class B or C, the eftgine should be diesel engine or internal combustion engine, exhaust pipe should be in front of the tank or load and fitted with an approved spark arrester and silencer or muffler, the engine intake or air cleaner should have flame arrester, fire resisting shield between the cab and the tank or load (i.e. rear side), fuel tank with stout steel guard and lock in the filling caps (R.70).

Electrical installation should not exceed 24 volts, wiring should be heavily insulated and adequate for maximum load, should have over current protection (fuses or automatic circuit breakers) encased in covering, sealed junction boxes, heavy duty switch to cut off battery and generators, motors and switches of flameproof type if not installed within engine compartment (R.71).

Portable fire extinguisher necessary (R.72). Vehicle should be constantly attended by a person who knows these rules (R.73). No parking on a public road or in congested area or in 9 mt. of any source of fire (R.74). Licence to transport necessary (R.75). Loading, unloading in a licensed premises only (R.76). Leaky, defective or unlicensed tank vehicle should not be filled (R.77).

Precautions against static charges include earthing and electrical continuity of pipelines, earth boss with a flexible cable and clamping device, earthing of tank, filling pipe and chassis during loading, dip-rod should not be completely raised above the liquid level during or within one minute of the completion of loading. Filling rate should not exceed I mt/sec until the filling pipe is completely submerged and there after it may be gradually increased but shall not exceed 6 mt/sec at the delivery end. The CC can permit a faster loading rate in case of petroleum having higher conductivity rate (R.78).

Loading/unloading after stopping of the engine and battery isolated. Restart only after the tank and valves are securely closed (R.79). No movement of vehicle during loading/unloading (R.80). Product contamination to be avoided by selecting correct filling hose and refilling of tank of class A petroleum with any other petroleum only after draining of residual oil (R.81). Except during loading/unloading, the filling pipe, discharge faucet and dip pipe shall be kept securely closed (R.83). No loading/unloading during night hours except approved electric lights provided (R.83). No fire, light, smoking or articles to cause fire allowed on vehicle (R.84). No repair of tank unless certified by a competent responsible person (R.85). No petroleum to be carried with passengers save as provided (R. 86).

Part -V : Transport by Pipelines (R.87 to 101) :

This part is applicable to petroleum pipe lines other than those in the area of operation of natural gas and/or oil or within refineries and installations (R.87).

It provides for right of way to be acquired (R.88), approval from the CC obtained (R.89), design as per standard code or OISD Std. 141, made of suitable steel which is safe for conditions under which it is to be used, provision for expansion, contraction, prevention of excessive stresses, by pass relief valves, pressure limiting stations, automatic shut down equipment to prevent pressure rise more than 10% of the designed internal pressure, isolation valves at different locations (R.90), laying criteria (underground as far as possible) (R.91), protection against corrosion (R.92), hydraulic test (at I.I times the design internal pressure and maintaining for 24 hours) at an interval of 12 months (R.93), shut down procedure (R.94), patrolling of pipeline, communication facilities at frequent intervals along the pipeline of length more than 2 km (R.95), checking of gauges at tanks or booster pump stations at least once a year (R.96), addition, alteration only after approval from the CC (R.97) and power of the CC to require relay or repair for public safety (R.99) and of inspection and examination (R.IOO). The fire or major leakage in a pipeline or connected facilities should be reported immediately by the person in-charge of the pipeline to the nearest magistrate or police station and by telegram to the CC, Nagpur (R.IOI).

Repair and maintenance of pipeline u/r 98 includes

1. Inspection by an experienced engineer for assessment of work.
2. written work permit specifying precautions to be observed and procedure to be followed.
3. The section of the pipeline shall be isolated, drained and purged with inert gas or steam or kept filled with water or treatment approved by the CC.
4. Work of cutting or welding to be carried out by an experienced person in accordance with the permit
5. Only mechanical cutters shall be used for cutting the pipeline or any connection thereof unless it has been purged with an inert gas.
6. Separation of pipeline or valve fitted to it only after providing electrical bond between the parts, to be separated and the bond shall not be broken till the parts have been rejoined.
7. Reuse of the repaired section only after hydrotest as stated in rule 93.

Chapter-IV : Electric Installation (R. 102 to 115) :

Electric wiring and apparatus to be used in any place where petroleum is refined, blended, stored, loaded or unloaded, should be in accordance with this chapter (R.102).

Classification of Hazardous Area (R. 103, 104) :

Hazardous area means where (i) Petroleum having FP below 65bC or any inflammable gas or vapour capable of ignition is likely to be present or (ii) Petroleum or any inflammable liquid having FP above 65°C is likely to be refined, blended, handled or stored at or above its FP. (R. 103).

It is classified as under :

Zone	Condition
0	Where inflammable gases / vapours are likely to be continuously present.
1	Where they are likely to be present under normal operating conditions.
2	Where they are likely to be present only under abnormal operating conditions to failure of rupture of an equipment.

Thus zone 0 is more hazardous than zone 1 an zone 1 more hazardous than zone 2. On any question regarding applicability of these divisions, the decision of the CC shall be final (R.104).

Extent of hazardous area is laid down in the 4th Schedule. The CC can increase or reduce it based on special circumstances (R.105).

Fixed Electrical Apparatus (R.106) :

Zone		**Type of Apparatus approved by CC.**
0		Intrinsically safe
1	(i)	Intrinsically safe or a flameproof type, or
	(ii)	Industrial type apparatus housed ii enclosure or in a room made safe b" purging or pressurising atmosphere and interlocked to stop electric supply automatically or to give warning to stop it in case of failure of the purging or pressurising system.
2	(i)	Non sparking apparatus or
	(ii)	Apparatus permitted in Div. 1.

Fixed Electric Wiring (R.107) :

It should be effectively sealed at all joints, mechanically protected, adequately supported and consisting of approved armoured cable or metal sheathed cable or insulated cables in a galvanised conduits with approved flame proof fitting or mineral insulated cable of approved type with flameproof glands at all joints and details mentioned in the rule.

Earthing and Bonding (R. 108) :

Electric systems and equipment should be earthed with resistance of 4 ohms or a value that ensures the safe operation of the protective device in the circuit whichever is lower.

All non-current carrying metallic parts of electric apparatus or other metallic objects should be earthed with resistance of 10 ohms.

All joints in pipelines, valves, plants, storage tanks, associated facilities and equipment for petroleum shall be electrically bonded with the resistance value between each joint not exceeding I ohm.

Other Provisions:

Cathodic protection as in rule 109. Electrified railway systems (overhead lines and live contact rails) are not allowed within a refinery or an installation. They should be terminated outside the area where tank wagons are loaded or unloaded. Both the rails of spur lines shall be insulated from a railway siding which is used for the loading or unloading of tank wagons (R.IIO). Portable electric apparatus or lamp of 25 volts, approved by the CC (Who can permit up to 55 volts) can be used in a hazardous area (R.lll). Maintenance to retain characteristics (R.112). Repair and test after cutting off voltage. In zone I area, after gas-testing and certified safe by a competent person (R.113). Certificate of electric installation by a competent person (R.114). Precautions against corrosion (R.115).

Chapter -V : Storage of Petroleum requiring licence (R.116 to 135):

Licence necessary (R.116). Precautions against fire OISD Std. 117, DCP and other fire extinguishers (R.117). Experienced supervisor necessary (R.118). Cleanliness (R.119). Drainage (R.

120). Wall or fence of at least 1.8 mt. height to prevent unauthorised entry 1.2 mt height for service stations (R.121). Marking of capacity on tanks (R.123). Construction of tank by iron or steel and as per IS. Foundation of non combustible material. Air space 75% or as per Code (R.124)and protection against corrosion by protective coating or cathodic protection etc. (R.125).

Before use the tank should be tested by water pressure by a competent person. It shall not be passed through any pipe or pump ordinarily used for the conveyance of petroleum. Proforma of certificate of such testing is given u/r 126.

Tanks should be earthed by two separate connections placed at opposite extremities. The resistance to earth shall be less than 7 ohm and that of the earth plate shall be less than 2 ohm, (R.127.) Testing of earth connection necessary once in I year by a competent person. Its record should be maintained (R.128). No night working unless approved electric lights provided as per chapter - IV (R.129).

Certificate of Safety is required from a competent person by the licensing authority in a proforma given u/r 130.

Prior approval of specifications and plans of premises required u/r 131. Electric motor or internal combustion engine to drive pumps for pumping petroleum should be got approved by the CC (R.132). Licence number should be marked on premises (R.133). An extract of certain rules to be displayed (R.134).

Chapter - VI : Storage of Class - C Petroleum not requiring licence (R. 136 to 140) :

Provisions of previous chapter-V are not applicable to class-C petroleum to be stored without licence u/s 7 (R.136). It shall not be stored together with other class of petroleum except as permitted by licence (R.137). Bulk storage tank should be approved by the CC. Tanks of more than 5000 litres capacity should have dyke or be placed inside a pit to contain at least the volume of the largest tank within it. A drainage pipe with valve fitted outside shall be provided and kept closed. A distance of more than 1.5 mt. shall be kept between the edge of dyke and any protected works (R. 138).

Class-C petroleum not in bulk, if exceeds at any one time 2500 litres be stored in a storage shed of which either the door way or openings are built up to a height 30 cm above the floor or the floor shall be sunk to a depth of 30 cm,. (R.139).

Prior report to store class C petroleum exceeding 5000 litres without licence shall be sent to the CC staling the location of the premises (R.140).

Chapter-VII of licences (R.141 to 161), Chap. IX of Tetraethyl lead mixtures (R.181 to 185), Chap. X of testing of petroleum (R.186 to 199), Chap. XI of notice of accident (R.200) and Chap. XII of exemption (R. 201, 202) are not discussed here. But abstract of Chap. VIII is given below.

Chapter-VIII: Refining of Petroleum (R. 162 to 180):

Project report with specifications and plans showing the arrangements of tanks, stills, furnaces, electric installations, pump houses, drainage, ETP, FFE, fencing, gates and all plants and buildings where it is proposed to refine, crack, reform or blend, petroleum (it is called refinery in this chapter) shall be sent to the CC in triplicate arid a scrutiny fee of Rs. 5000 (R.162). A copy each of the approved plans shall be kept at the refinery (R.163). Alterations are also to be approved (R. 164).

Fireproof materials should be used in buildings where petroleum is to be handled (R.165). Storage tanks should be more than 90 mt. away from any still, boiler or furnace (not applicable to class C fuel tank for a boiler if the tank capacity not exceeding 24 hours stock) (R.166). Storage tanks of LPG or its filling facility should be more than 90 mt. away from any still, boiler or furnace or 30 mt. away from any storage tank, pump-house or facility for blending or filling of petroleum or from any protected work (R.167). Flare shall also be 90 mt. away from any tank, still, pumphouse or any refinery activity or LPG (R.168).

Effluents and drainage should not cause any pollution or harmful effect on animal or vegetable life. Weekly samples shall be drawn and tested in the refinery laboratory for their oil content, acidity, alkalinity and record be maintained (for at least 6 months) and shown to an Inspector. The sewerage shall be independent of other drainage system. All drains shall have adequate capacity to prevent any flooding or backing up and of such construction to prevent leakage or be affected by the chemicals in contact. Trash racks (grills) to be fitted to prevent entry of rubbish to form a plug. Manholes, verits to release gases, fire-traps and gas traps on the upstream side of the oil interceptors and fitted with vents to liberate gas at a safer height are also to be provided (R.169).

No fire/source of heat or light capable of igniting inflammable vapours shall be allowed except in the firing spaces, stills or boilers. Smoking not permitted except in places specially approved by the CC (R.170).

Work permit from a competent person is necessary for maintenance and repair work and entry into confined spaces, closed drain or manhole. It shall be issued for a limited period during which known conditions will remain safe and after inspection and testing by the competent person, for gases and lead content will be carried out by suitable trained persons and with standard instrument (R. 171).

For fire control a well organised and trained fire fighting service with necessary materials and fixed, mobile and portable equipment is required. OISD Std. 116 should be followed. Adequate water supply should be available at all strategic points by means of an independent ring main or grid with isolating valves. The main shall be kept constantly pressurised by two or more boosting pumps of adequate capacity and working automatically when pressure drop occurs in the main. At least one boosting pump should be independent of power supply (e.g. diesel driven). All mains shall be fitted with hydrants at convenient places not more than 30 mt. apart. If mains water supply is likely to be interrupted, static water supply of adequate capacity shall be provided. Training for personnel necessary (R. 172).

All petroleum as it leaves the stills may be pumped back to services tanks for fuel or refinery storage tank and not be stored in the vicinity of stills and boilers (R. 173) Danger from static electricity shall be prevented (R. 174). Warning notices to be displayed (R. 175). All above ground pipelines and cables shall be identified by taping, stencilling, colouring etc. Pipelines, valves, route of underground cables and route of overhead pipelines and cables crossing roads shall be protected against damage (R. 176). All plants, instruments and equipment shall be inspected, tested and records maintained (R. 177). All operators shall be trained in safe operation. Written procedures shall be established to start up, shut down, gas free plants and emergency actions. Supervisors shall ensure safe operation and safety facilities (R. 178).

An occurrence of fire shall be reported immediately to the CC and to the nearest police station (R. 179). When refinery is closed down the area within the fence shall be cleared of all petroleum having FP $< 93°C$ as soon as possible (R. 180).

Table 1, 2 & 3 for safety distances are important for plant layout. Third schedule gives design and construction of 'Tank vehicles' for transporting petroleum in bulk.

3.3 Explosives Act, 1884 :

This Act (4 of 1884) was enacted on 26-2-1884. It came into force from 1-7-1884. It extends to the whole of India. It has 18 sections.

Its object is to regulate the manufacture, possession, use, sale, transport, import and export of explosives.

Explosive as defined in Sec, 4(d) means gunpowder, nitro-glycerine, nitroglycol, guncotton, di-nitro-toluene, tri-nitro-toluene, picric acid, di-nitrophenol, tri-nitro resorcinol (styphnic acid) cycio trimethylene-tri-nitroamine, penta- erythritol tetranitrate, tetryl, nitro guanidine, lead azide, lead styphynate, fulminate of mercury or any other metal, diazo-di-nitro phenol, coloured fires or any other substance, whether a single chemical compound or a mixture of substances, whether solid or liquid or gaseous used or manufactured with a view to produce a practical effect by explosion or pyrotechnic effect and includes fog-signals, fire works, fuses, rockets, percussion-caps, detonators, cartridges, ammunition of all descriptions and every adaptation or preparation of as an explosive as defined in this clause.

Aircraft carriage and vessel are also defined in this section.

Main Provisions:

1. A person below the age of 18 years, offender of violence or moral turpitude, who is ordered to keep peace or good behaviour or whose licence is cancelled for any offence under this act, cannot manufacture, sell, transport, import or export, deliver or dispatch or possess any explosive defined or notified. (Sec. 6A)
2. Licence can be granted, refused, varied, suspended, revoked and conditions can be imposed (Sec. 6B to 6E). Appeal can be preferred as per sec. 6F.
3. The Central Government has power to make rules regarding inspection, search, seizure, detention and removal (Sec. 7).
4. Notice of accident is required u/s 8 and its inquiry shall be conducted u/s 9. The Central Government can inquire into more serious accidents (Sec. 9A).
5. Explosives with receptacles shall be forfeited by the court after conviction (Sec. 10).
6. Abetment and attempt to commit offence under this Act or Rules is punishable (Sec. 12).
7. Any person found committing any offence punishable under this Act can be arrested without warrant, be removed from the place and conveyed before a magistrate (Sec. 13).
8. The Central Government can delegate its power to State Government or an officer u/s 17A.

3.4 Explosives Rules, 1983 :

U/s 5 and 7 of the Explosives Act, 1884, these rules were published on 2-3-1983. They have 10 chapters, 186 rules, 8 Schedules, 40 Forms under Schedule V and 8 specifications (guidelines) under schedule VII. Last schedule VIII gives safety distances in two tables. Five annexure are given at the end. Exhaustive details are provided of which a short abstract is given below :

Definitions : Chief Controller of Explosive (CCE) is the main authority. He can recognise a competent person by giving him a certificate of competency. Prohibited explosives mean that u/s 6, authorised explosives mean those published by the Government and permitted explosives mean those permitted by the Director General of Mines Safety to be used in underground coal mines.

Detonator, safety cartridge, safety fuse, safety zone etc. are defined. Magazine means a building to store more than 5 kg of explosive and specially constructed as approved by the CCE. Protected works include a dwelling house, college, school, hospital, theatre, factory, storage of hazardous substances, public road, railway, waterways, dams, reservoirs, high tension power lines. Safety zone is a distance required between such protected work and a licensed factory, magazine or store-house.

Safety Distance Categories of Explosives : According to the risks, they are as under :

Category	Explosives
X	Which have a fire or slight explosion risk or both but the effect is local.
Y	Which have a mass fir risk or a moderate explosion risk but not the risk of mass explosion.
Z	Which have mass explosion risk and major missile effect.
ZZ	Which have mass explosion risk and minor missile effect.

On any question of category, decision of the CCE shall be final.

General Provisions (Chap-11, Rule 5 to 20) :

1 Import, export, transport, manufacture, process, use or sell of unauthorised explosives is prohibited. Testing and trial are permitted in a licensed factory. (R.5).

2 Application for authorisation of explosives is necessary. Particulars are prescribed for submission. A sample shall be sent as per instruction from CC (R. 6).

3 Tests prescribed [R. 6 (6)]

(1) Physical properties including consistency, reaction, tendency to absorb moisture, segregation of the constituents, exudation, behaviour at low temperature, specific gravity etc.

(2) Chemical composition- percentage and quality of ingredients.

(3) Stability - effect of environmental conditions which would produce spontaneous ignition or variation in sensitiveness.

(4) Ignition characteristics- ignition point, behaviour, liability to spontaneous ignition.

(5) Mechanical sensitiveness to friction and impact.

(6) Air gap sensitivity and transmission of detonation..

(7) Velocity of detonating.

(8) Strength determination.

(9) Gases evolved upon explosion.

(10) Such other tests specified by the CCE.

(11) Any other test required by CCE.

4. Delivery and Dispatch under licence and not exceeding the quantity (R.7).
5. Packing as per Schedule H and after approval of the sample (R. 8).
6. Marking of packages should mention the word "EXPLOSIVES" (not required for fireworks and safety fuse), name of the authorised explosive, class number and division, safety distance category, names of manufacturer, consignor and consignee, net weight and letter 'V for permitted explosive (R.9)
7. Weight of explosive shall not include the weight of the packing box (10.)
8. Competent person should be in-charge of operations (R.11)
9. Precautions in handling- Floor should be checked, cleaned and swept before and after use. The packages shall not be thrown, dropped, rolled or pulled but shall be passed from hand to hand and carefully deposited. A slung package should be prevented from fall (R. 12).

10. Handing between sunset and sunrise is restricted unless proper lighting and guarding is provided. (R. 13).
11. Within 15 mt. of an explosive storage or at its place of handling or transport, smoking, fires, lights and flammable substances or substances to cause fire or explosion such as acids, petroleum, calcium carbide, compressed gases shall not be allowed (R. 14)
12. No person will carry matches, knives, fuses, iron or steel or wear shoes with iron nails (R. 15).
13. Split explosive shall be safely destroyed (R. 16).
14. Employment of person below 18 years, intoxicated persons and persons of unsound mind is prohibited (R. 17).
15. Precautions against danger from water (in compatible) or exposure to sun or heat are necessary (R. 18).
16. Special precautions against accident (fire or explosion), thefts, entry of unauthorised person near explosives are necessary. (R. 19).
17 Nitro-glycerine or Ethylene glycol dinitrate or explosives of Class-5, unauthorised, deteriorated or damaged explosives shall not be transported without approval of CC, except within the licensed factory solely for the purpose of manufacture of explosives (R. 20).

For classes of explosives see Sch. 1.

Import & Export (Chapter-111, Rule 21 to 31) :

Licence necessary (R. 21). Rules for import and export by sea, land and air are prescribed.

Transport (Chapter-IV, R 32 to 86):

Licence necessary (R. 32). Certain explosives cannot be transported together (R. 33). Safety certificate is required (R. 34). No transport of explosives with passengers (R. 35). Maximum weights as per R. 36. Loading and unloading procedure (R. 38 to 45.). Transport by water (R. 46 to 61) Transport by Rail (R. 62 to 74). Transport by Road (R. 75 to 86). Licence for road van necessary. Towing not allowed. Four wheel chocks to be carried all the time. In case of fire, traffic to be stopped 300 metres away. Accident to be reported. Two fire extinguishers of 2 kg or ..more capacity required with road van.

Manufacture (Chapter-V, Rule 87 to 112) :

Licence necessary (R.87) and not necessary (R. 88). Approval of CC required (R. 89) Factory should have a wall or fencing 2 mt. high to prevent unauthorised entry (R. 90). Interior should be free from grit, iron or steel and kept clean (R. 92) . Surrounding mound or blast wall as approved by CC (R. 93). Oiled cotton, rags or waste not allowed to avoid spontaneous ignition (R. 94). Non-sparking tools made of wood, copper, brass or soft metal should be used (R. 95). Notice of maximum quantity of material and persons in a work room to be exhibited on process building (R. 96). Smoking prohibited (R. 97). Lightning conductor as per IS 2309, yearly checking of earth resistance and its notice are necessary (R.98). During thunder-storms work should be suspended and workers to be withdrawn to a safe place (R.99). Foreign matter in ingredients to be removed (R.IOO). Protection against fire. Cloths without pockets (R.IOI) Residues will be quickly removed (R.102). Before carrying out repairs to building, explosives shall be removed (R.103). Employment of competent person for process supervision (R.104). Birth or fitness certificate is necessary for age between 18 to 21 (R.105). Every vehicle, trolley or receptacle to carry explosives shall be free from iron steel etc. and be covered or closed (R.106). Maintenance of building, plant and equipment should be regular and good. (R.107). Testing facilities as approved by CC (R.108). Safe disposal of waste explosives (R.109). Unsafe process to be stopped (R.IIO). Up to date records to be maintained for 2 years (R. 112).

Possession, Sale and Use (Chapter-VI, Rule 113 to 153):

Licence necessary (R.113) and not necessary (R.114). Use of licensed premises only (R.115). Protection from lightning (R.116). Precautions during thunderstorm (R.117). Building to be kept clean (R.118 & 120). Maintenance of records (R.119). Hazardous articles not to be carried. Search for them and for cloths without pockets and suitable shoes (R.121). Premises to be kept locked (R.122). Security Guards for .round the clock (R.123). Repackaging or opening at safe place and safe distance (R.124). Explosives not to be kept in damaged boxes (R.125) No storage exceeding licensed quantity (R.126). Magazine storage in mode A or B as specified in Sch. VII (R.129). Surrounded by mound (R.131) and on ground floor only (R.132). Storehouse of sound .construction (R.134). Type of premises, ground level minimum floor area 9m2, separate entry and exit (R. 135). Special precautions to be observed for fire works (R.136). Safety distance 15 mt. or more from storage of explosives, flammable or hazardous materials (R.137). No sale of other articles (R.138).

Use of Explosives : Competent person to be employed (R.144). Restrictions on preparation of charges (R.145). Restriction to carry at the blasting site (R.146). Examination before use (R.147). Precautions at site (R. 148),. Warning procedure (R.149). Precautions while firing (R.150), against stray currents (R.151) fire, or accident (R.152). Blasting, operations under the Mines Act, 1952 are allowed.

Licences (Chapter VII, R 154 to 174).

Fees (Chapter VIII, R. 175 to 177).

Powers and Penalties (Chapter IX R. 178 to 181).

Accidents and Enquiries (Chap. X, R. 182 to 186).

Notice forthwith to the CCE, Nagpur, CE under jurisdiction and nearest police station (R.182). Procedure at courts of inquiry (R.183). Inquiry by a District Magistrate or a Police Commissioner (R. 184). Inquiry into more serious accidents (R. 185).

Schedule I (R. 3) Classes of Explosives :

Class 1	Gun-powder.
Class 2	Nitrate-mixture
Class 3	Nitro-compound
Class 4	Chlorate-mixture
Class 5	Fulminate
Class 6	Ammunition
Class 7	Fireworks
Class 8	Liquid Oxygen Explosives.

Detailed list of chemicals is given under each of these classes.

Schedule II (R. 8)	Packing of explosives
Schedule III (R. 21)	Methods of Testing
Schedule IV (R.155)	Licensing Authority
Schedule V	Forms 1 to 40
Schedule VI	Explosives permitted to be imported and transported by air
Schedule VII	Specifications as under

Specification No. For

1	Road Van to carry explosives
2	Motor truck together with compressor unit
3,4 & 5	Metal cases for conveyance of explosives
6	Magazines (Storage), Mode A&B
7	Store-house
8	Compressor mounted motor truck or tractor Sch. VIII Safety distances

3.5 Static and Mobile (Unfired) Pressure Vessels Rules, 1981 :

U/S.5 and 7 of the Explosives Act 1884, the' Central Government notified these rules w.e.f. 5-2-1981. They have 8 chapters, 69 rules, 3 appendices, 2 schedule and 5 forms.

The rules were amended in 1993, 2000 and 2002. Chapter-1: Preliminary (R.I to IIA) :

Definitions : Out of (a) to (z) definitions, majority are scientific and therefore they are reproduced below.

1. "Permanent Gas" means a gas whose critical temperature is lower than 10°C.
2. "Liquefiable Gas" means any gas that may be liquefied by pressure above 0°C, but will be completely vaporised when in equilibrium with normal atmospheric pressure (760 mm HG) at 30°C;
3. Cryogenic liquid means liquid form of permanent gas having normal boiling point below minus 165° C.
4. Critical temperature means the temperature above which gas cannot be liquefied by the application of pressure alone.
5. "Compressed gas" means any permanent gas, liquefiable gas or gas dissolved in liquid or cryogenic liquid under pressure or gas mixture, which in a closed pressure vessel exercises a pressure exceeding one atmosphere (gauge) at the maximum working temperature and includes Hydrogen fluoride. In case of vessels without insulation or refrigeration, the maximum working temperature shall be considered as 55°C.
6. “Design" includes drawings, calculation, specifications, models, codes and all other details necessary for the complete description of the pressure vessel and its construction;
7. LPG i.e. Liquefied Petroleum Gas includes hydrocarbon gases in liquefied state at normal ambient temperature by the application of pressure, and conforming to the IS : 4576.
8. Dispenser means an equipment installed in LPG dispensing station, meant for dispensing LPG as automotive fuel to motor vehicles;
9. "Design pressure" means the pressure used in the design calculations of a vessel for the purpose of determining the minimum thickness of the various component parts of the vessel;
10. "Filling density" means the ratio of weight of liquefiable gas allowed in a pressure vessel to the weight of water that the. vessel will hold at 15°C;
11. "Flammable compressed Gas" means gas 13 percent or less of which when mixed with air forms a flammable mixture or whose flammable range with-air is greater than 12 percent;
12. "Gas Free" in relation to a pressure vessel means the concentration of flammable or toxic gases or both if such pressure vessel is within the safe limits specified for persons to enter and carry out hot work in such vessels;
13. "Pressure Vessel or Vessel" means any closed metal container of whatever shape, intended for the storage and transport of any compressed gas which is subjected to internal pressure and whose water capacity exceeds 1000 litres and includes inter connecting parts and components thereof up

to the first point of connection to the connected piping and fittings but does not include containers wherein steam or other vapour is or is intended to be generated, or water or other liquid is or is intended to be heated by the application of fire or the product of combustion or byelectrical means, heat exchangers, evaporators, air receivers, steam-type digesters, steam-type sterilises, autoclave, reactors, calorifiers, pressure piping components such as separators or strainers and vessels containing a liquid under a blanket of compressed inert gas.

14. "Safety relief device" means an automatic pressure relieving device actuated by the pressure upstream of the valve and characterised by fully opened pop action, intended to prevent the rupture of a pressure vessel under certain conditions of exposure;

15. "Source of ignition" means naked lights, fires, exposed incandescent materials, electric welding arcs, lamps other than those specially approved for use in flammable atmosphere, or a spark or flame produced by any means;

16. "Water Capacity" means capacity in litres of the pressure vessel when completely filled with water at 15°C.

The vessel should be manufactured as per IS 2825 or code specified u/r 12 and approved by the CC, otherwise it cannot be filled or transported. Any person seeking to manufacture such vessels should apply to the CC in Appendix. I with a scrutiny fee of Rs. 500 (R.4).

Storage, delivery and dispatch as per licence only (R.5). Repair after approval from CC and as per IS-2825 (R.6). Before using or refilling any vessel for flammable gases, purging by an inert gas or by the gas to be filled with safe venting is necessary (R.7). Prohibition of employing a person under 18 years or intoxication and smoking or allowing source of ignition or any flammable gas (R.8 & 9). These rules are to be complied with and precautions to prevent accident are necessary (R.IO). Supervision is also necessary (R. 9A).

Procedure for paying fees is given u/r II and that for applying recognition as competent person or Inspector in Appendix III to the CC is -given u/ r II-A.

Chapter-II : Construction and Fitments of Pressure Vessels (R. 12 to 20):

Design Code - For design, construction and testing IS:2825 or other code approved by CC. Test and Inspection certificate issued by the manufacturer and countersigned by an Inspector shall be sent to CC. (R. 12).

Design pressure should not exceed the vapour pressure at 55°C if liquefiable gas is to be stored or the developed pressure at 55°C if permanent gas (whose critical temp. is < 10°C) is to be stored. For an insulated vessel it may be reduced corresponding to the maximum temperature likely to be attamed by the gas in the vessel. Maximum allowable service pressure with allowances for cryogenic liquid (R. 13).

Design for low temperature should be as per code mentioned in R.12. Refrigeration capacity should be adequate to maintain the vapour pressure below the design pressure and the set-pressure of a safety valve. Insulation material should be approved by CC,' cladding thickness more than 3 mm, water-tight and thermal conductance at 15°C should not exceed the limit prescribed by the CC (R. 14).

Filling capacity & pressure as per rule 15. The maximum quantity of liquefiable gas to be filled should not exceed the filling density (i.e. the ratio of the weight of the gas to the weight of water that the vessel will hold at 15°C) and the vessel should not become liquid full due to expansion of the gas at 55°C if the vessel is un-insulated or at such highest temperature attainable incase of refrigerated or insulated vessel. A permanent gas shall not be filled in excess of design pressure of the vessel (R. 15).

Marking on Vessels should indicate (1) Manufacturer's name and identification (2) Standard or code (3) Official stamp of the Inspector (4) Design pressure (5) Date of tests (6) Hydrostatic test pressure (7) Water capacity (8) Gas capacity and (9) Name or chemical symbol of the gas. (R. 16.)

Painting with reflecting surface (R. 17)

Fittings should include Pressure Gauge, Temperature Indicator, Safety Valve, Level Indicator and drains. Connections as per code in rule 12. There should be two (or more) pressure relief valves (SV) spring loaded type, set to start at a pressure below 110% of the design pressure and total relieving capacity to keep the pressure inside the vessel less than 120% of the design pressure. Connections to these Safety Valve should be of sufficient size to allow the required rate of discharge. There should be shut off valve between Safety Valve and the vessel. For static (not mobile) vessels of more than 4500 lit. water capacity, outlet of Safety Valve should extend 2 mt. above the top of the vessel and at least 3.5 mt. above the ground level. They should have loose fitting rain caps. Safety Valve should be tested once in a year by a competent person and record be kept.

All liquid and vapour connections on vessels (except Safety Valve, plugged openings and where diameter is less than (1.4 mm) should have shut-off (stop) valves as close to the vessel as practicable.

There should be an emergency shut off valve (for both liquid and vapour phase) such as an excess flow valve, automatically operated valve or a remotely controlled valve which can be operated from a safe place and which shall not fail. Such emergency shut off (stop) valve is not required if liquid connection is of less than 3 mm dia and vapour connection is of not more than 8 mm dia. Excess flow rate should easily allow the normal flow rate (should not cause valve chatter) but should have closing rate below the rate of discharge from a fracture of the line it is protecting, calculated under the worst condition possible.

Liquid level gauge should show a ready amount of liquid at any time. One maximum level indicator should also be provided. Bleeding device (rotary tube, fixed tube, slip tube) cannot be completely withdrawn in normal gauging operations. (R. 18).

Hydraulic testing of all vessels by a competent person at a pressure marked on the vessel is necessary .at 5 years intervals (2 years for corrosive or toxic gases.). Where water test is not possible or tolerable, CC may permit pneumatic testing along with NDT. Pneumatic test pressure for cryogenic pressure vessel shall be I.I times MPWP. Before each pressure test, the vessel shall be thoroughly cleaned and examined internally and externally for surface defects, corrosion, foreign matter and hazardous material (e.g. pyropheric sludge). After test it shall be thoroughly dried internally and stamped with marks, figures and test date. A vessel failing to pass hydraulic test or found unsafe for use shall be destroyed or rendered unsuitable under intimation to the CC. The competent person shall give a test certificate in prescribed proforma. A record shall be kept of all such tests (R. 19, 20).

Chapter -III : Storage (R. 21 to 33):

General : Compressed gas vessels shall be aboveground, first stage regulating equipment in open, vessels should not be one above the other, vessels in a group should have their longitudinal axes parallel, no location within petroleum or flammable liquid area, sufficient space between two vessels to permit fire fighting operations, two or more vessels in batteries should have their top surface on the same plane and vessels facing their dished ends should have screen wall in between them. Floor slope, sump, dyke and dimensions for corrosive, flammable or toxic gases in liquefied state (R. 21).

Minimum Safety Distances;

See table I to 7 u/r 22.

Foundations as prescribed in R. 23. Supports should be so anchored, weighed or at height to avoid flotation due to flood waters. Bottom supports upto 45 cm (max.) shall be encased in fire-resisting materials of adequate thickness.

Fencing of at least 2 mt. height with 2 exits opening out wards and not self locking. The fencing should enclose vessels, pumping equipment, vaporisers and loading/unloading facilities. (R.24).

Cleanliness An area of 3 mt. around the vessel shall be free from combustible material such as weeds and grass (R. 25).

Earthing Vessels and pipelines should be efficiently earthed and bonded (R. 26).

No smoking Notice with letters at least 5 cms size fixed on fence surface visible from outside where flammable or oxidising gases are stored (R. 27).

Fire Protection for the storage of flammable compressed gases should include sufficient supply of water, hydrants, hoses, mobile equipment, fixed monitors or automatic spray systems, control valves outside the danger area, jet & fog nozzles and at least 2 DCP type fire extinguishers of 9 kg each near each point of access to the installations. Special provision for LPG station (R. 28).

Loading and Unloading Facilities like pumps, compressors, transfer systems and hoses as prescribed in R.29. Remotely controlled shut-off valve for the vessel being filled or emptied. High level alarm interlocked with automatic shut off valve to prevent overfilling. The hoses should withstand not less than 4 times the maximum operating flow pressure in them and should be mechanically and electrically continuous (R.29).

Transfer operation should follow the detailed instructions u/r 30. Supervision by a competent person for compliance of these rules is necessary. Precautions to check vessel before and after filling, condition of piping, valves, fittings, hoses, vehicle and its earthing, prevention of overfilling, removal of spillage etc (R. 30). Provisions for LPG stations (R.30A & B).

Electrical wire should not pass over any storage vessel and all electrical wires installed within the safety zone or storage of flammable gases should be of approved insulated cables type. In a pump room for pumping flammable gases, all electric apparatus and fittings should be flameproof conforming to IS:2148 and frames shall be earthed. Lamps should have flameproof glass fittings conforming to IS:2206 (Part1). Portable hand lamps should have been approved by the CC (R.31). Classification of hazardous area in Zone 0, I & 2 (R. 31 A & B).

Lighting should be of approved type, other wise no operation to be carried out during night (R.32).

Safety Certificate in the prescribed proforma signed by a competent person should be furnished to the licensing authority (R.33).

Chapter - IV : Transport (R. 34 to 44):

This chapter is applicable for the transport of compressed gas by vehicles (R.34). Drawings of the vehicle and its special fittings should be got approved by the CC (R.35). Design considerations are given in rule 36 to 39. Protection of valves, accessories, piping, fittings, pumps and vessel are suggested. Mechanical, electrical and general design safety requirements arfe prescribed- Product should be marked on the vessel (R.40). Fire protection includes prohibition of smoking or carrying matches, lighters or any flammable substance (R.41). Driver should be a trained one. While loading/unloading presence of a competent person is necessary. Safe parking during overnight stop (R.42). A safety certificate in prescribed proforma signed by a competent person shall be furnished to the licensing authority before using any vehicle for such transport (R.43). The vehicle shall be maintained in a fit condition and examined every 6 months by a competent person and certified in a prescribed proforma (R. 44).

Chapter-V (R. 45 to 64) is regarding Licences, Chapter VI (R. 65) for exemption. Chapter VII (R. 66 to 68) for Accidents and Inquires and Chapter VIII (R. 69) for powers of CC and subordinate controllers, of District Magistrates, the Police Commissioners and their subordinates.

Accident should be reported to the CC (by Telegram and a letter within 24 hours) and forth with to the nearest police station.

Appendices are as under :

Appendix – I : Application to manufacture a vessel. .
Appendix – II : Qualification and Experience of Inspector and Competent person.
Appendix – III : Application for recognition as competent person.

3.6 Gas Cylinders Rules, 2004 :

Replacing Gas Cylinders Rules, 1981, these rules of 2004 came into force from 21-9-2004.

It has 10 Chapters, 73 Rules, 6 Schedules and Forms A to G u/sch. V.

Chapter-1: Preliminary (R 1, 2) :

Definitions (R. 2) : Out of 43 definitions majority are scientific definitions. Therefore, they should be referred from the statute book.

Some definitions are given below.

1. **"Auto LPG"** means liquefied petroleum gas meant for automotive fuel conforming to specification IS : 14861;
2. **"Composite Cylinder"** means a cylinder made of resin impregnated continuous filament wound over a metallic or a non-metallic liner. Composite cylinders using non-metallic liners are referred to as all-composite cylinders;
3. **"Compressed Natural Gas (CNG)"** means mixtures of hydrocarbon gases and vapours, consisting mainly of Methane in gaseous form, which has been compressed for use as automotive fuel;
4. **"Gas Cylinder"** or **"Cylinder"** means any closed metal container having a volume exceeding 500 ml. but not exceeding 1000 litres intended for the storage and transport of compressed gas, including any liquefied petroleum gas (LPG) container/compressed natural gas (CNG) cylinder fitted to a motor vehicle as its fuel tank but not including any other such container fitted to a

special transport or undercarriage and includes a composite cylinder, however, the water capacity of cylinders used for storage of CNG, nitrogen, compressed air, etc. may exceed 1000 litres up to 2500 litres provided the diameter of such cylinder does not exceed 60 .cm.;

5. "Liquefied Petroleum Gas" (LPG) means any material, which comprises predominantly of any of the following hydrocarbons or mixture of them with vapour pressure not exceeding 16.87 kg/Cm2 (gauge) at 65° C:- Propane (C_3H_8), propylene (C_3H_6), butane (C_4H_{10}), (n-butane and isobutene) and butylenes (C_4H_8);
6. "Poisonous (toxic) gas" means a gas which has a maximum allowable concentration in air for human respiration not exceeding 100 mg/ 3 at 15"C and I kgf/.cm2 absolute pressure;
7. "Yield strength" means the stress corresponding to a permanent strain of 0.2 per cent of the original gauge length in a tensile test. For practical purposes it may be taken as a stress at which elongation first occurs in the test piece without the increase of load in a tensile test.

Chapter-II : General Provisions (R. 3 to 28) :

1 **Cylinders** and valves should have been constructed as specified in Sch. I, test and inspection certificate should be available with information in Sch. II. Any person desiring to fabricate cylinders valves regulators and other fittings should apply in Sch. Ill (R.3).

2 **Valves** should be of the IS, type and design prescribed in R.4.

3 **Safety Relief Devices** fitted on cylinders should be as per IS 5903. Cylinders containing poisonous or obnoxious gases (as named) should not have such device (R.5).

4 **Marking on Cylinders :** as per rule 6.

5 **Markings of Valves :** as per R.7.

6 **Identification Colours :** as per IS:4379 for industrial cylinders and IS 3933 for medical cylinders. New gases and gas mixtures for which such colours are not provided in IS, shall be painted with following colours.

Type of Gas	Cylinder Shell	Band at neck
Non-flammable & non-Toxic	White	-
Non-flammable but Toxic	White	Yellow (IS 356)
Flammable & Non-toxic (other than LPG)	White	Red (IS 537)
Flammable & Toxic	White	Red & Yellow (IS 537 & 356)

Cylinders of gas mixtures should be marked "Gas mixture" or "mixed Gas" (R. 8).

7 **Labelling** of cylinder shall show the name of the gas and address of its filler. A warning notice should be attached to it with instructions that : (i) the colour of the cylinder will not be changed. (ii) No other gas will be filled in it. (iii) N o flammable material should be stored in or near die room of the cylinder, (iv) No oil or lubricant should be applied on valves or fittings, (v) No cylinder should be accepted whose test date is over(R.9).

8 **Restriction ;** No delivery or dispatch except to licence holder, defence forces, port or railway authorities (R.IO). Restriction on filling named gases and to endanger serviceability (R.19).

9 **Repairing :** not allowed except as otherwise provided in R.ll & 12.

10 **Prohibition** of employment of a person below 18 years or intoxicated (R.13) and on smoking or allowing fires, lights, or flammable substances, except blow pipe flame for repairs (R. 14).

11 **General Precautions** are that the cylinders should be maintained in good condition, oil, or lubricant not to be used on valves or fittings, no exposure to sun, high temperature of flammable/explosive material, security nut on a compressed gas cylinder and uncontrollable leaky cylinder to be removed in an open space and the filler be informed (R.15).

12 **Special precautions** are to avoid accident due to fire or explosion and to comply with these rules and licence conditions (R.I 6).

13 **Competent person** should supervise operations (R.17). '

14 **Handling & Use** include proper support, adequate strength of trolley and cradle, careful handling to avoid shock, no sliding, dropping, knocking, rolling or playing with cylinders, liquefied gas cylinders to be kept upright and work places should not be shown as storage places for the purpose of licensing (R.I 8).

15 **Storage precautions** to be observed are :

(1) To store in a dry, cool, under cover, well ventilated place and away from source of heat or ignition.
(2) Room of fire resistant construction.
(3) LPG and dissolved gas cylinders should be kept in upright position.,

(4) Flammable and toxic gas cylinders should be kept separate by a partition wall.
(5) Conditions to cause corrosion or fire should be avoided.
(6) Filled and empty cylinders should be segregated (R.21).

16 **Electrical installation** should be flameproof conforming to IS 2148 and effectively earthed (R.22).

17 **Impurities** in gas to cause corrosion or explosion should be avoided. The gas should be dry, moisture less than 0.02 g/m' of gas, aqueous phase cannot be separated at 0"C and free from sulphurous impurities (R.23).

18 **Cylinder subjected to fire shall** not be reused except after proper repairs and testing. Such acetylene cylinders are to be condemned or destroyed safely (R.24).

19 **Charging** after prescribed periodical re-testing only (R.26).

20 **Owner** has to keep prescribed record (R.27).

21. **Conversion** to cylinder not allowed without permission (R.28).

Chapter - III : Importation of Cylinders (R. 29 to 34):

Licence necessary (R.29). Importation by sea, land and air after permission from the Custom Collector, Central Government and Director General Civil Aviation only (R.30 to 34).

Chapter - IV : Examination & Testing (R. 35-36) :

Periodicity as per 15 or approval by the CC, testing station should have facilities set forth in Sch. IV (R.35).

Condemning of cylinders as prescribed. Any cylinder which fails to pass any test or examination or loses its tare weight by over 5% or found unsafe, shall be destroyed by flattening or cut into pieces so that it cannot be joined to form a cylinder. All markings shall be defaced and record be kept.

Service life of CNG cylinders 20 years and that of LPG containers 15 years (R.36).

Chapter-V is for dissolved Acetylene gas cylinders (R.37 to 42).

Chapter-VI is for filling, possession and their licence procedure (R.43 to 65), Chapter-VII on power to exempt (R.66) Chapter-VIII on Accidents and Inquires (R. 67 to 69) and Chapter-IX on powers of Controller of Explosives (R.70 to 73).

4. LAWS ON INSECTICIDES :

4.1 Insecticides Act, 1968 :

This Act (46 of 1968) was enacted on 2-9-1968. It came into force from 1-3-1971 (Sec. 4,7,8, & 36) and 1-8-1971 (remaining part). It extends to the whole of India. It has 38 sections and a .schedule listing insecticides amended from time to time.

It is an Act to regulate the import, manufacture, sale, transport, distribution and use of insecticides with a view to prevent risk to human beings or animals and matters connected therewith.

Provisions are made for the Central Insecticides Board, its committees, procedure and officers (S.4 to 8), Registration of insecticides, appeal and revision (S.9 toll), Licensing (S.12 to 15), Central Insecticides Laboratory (S.16), Prohibition of import and manufacture (S.17), Sale, stock, distribute, transport, use etc. (S.18) Insecticide Analysis (S.19), Inspectors (S.20 to 23). Report of Insecticides Analyst (S.24), Confiscation of stock (S.25) Notice of poisoning (S.26), Prohibition of sale etc. for reasons of public safety (S.27), Cancellation of registration (S.28), Offences & punishment (S.29), Defences which may or may not be allowed (S.30), Cognisance & trial (S.31), Special courts (S. 31A), Offences by companies (S.33), Power of Central Govt. and State Govt. to make rules (S.36 & 37) and Exemption (S.38).

By various notifications from 1989 to 1996, many insecticides are banned or restricted in India, e.g. DDT, chlorobenzilate, BBCP, PCNB, Toxaphene, Aldrin, Chlordane Heptachlor, Tetradifon, Nitrofen, Benzene Hexachloride etc.

4.2 Insecticides Rules 1971 :

These rules came into force on 30-10-1971. They have 9 chapters, 46 rules, 2 schedules and 22 forms. Chapter-1 gives definitions.

Tests' means any insects, rodents, fungi, weeds and other forms of plant or animal life not useful to human being s [R. 2 (h)]

'Laboratory' means the central insecticides laboratory. [(R. 2(e))].

Commercial Pest Control Operation means any application or dispersion of insecticide(s) including fumigants in household or public or private premises or land and includes pest control operations in the field including aerial applications for commercial purpose but excludes private use.

Pest Control Operator means any person who undertakes pest control operations and includes the person or the firm or the company or the organisation under whose control such a person(s) is operating.

Chapter-n is regarding the Board and its functions (R.3 to 5), Chapter-111 regarding registration of insecticides (R.6 to 8), Chapter-IV for grant of licences (R.9 to 15), Chapter-V for packing & labelling (R.16 to 20), Chapter-VI for insecticides analysts and Insecticides Inspectors (R.21 to 34), Chapter-VII for transport & storage (R. 35 to 36), Chapter-VIII for protective clothing, equipment and other facilities for workers (R.37 to 44) and Chapter-IX miscellaneous (R.45 to 46).

The first schedule prescribes 22 forms of which the last one (for medical examination of workers) is reproduced in this part. Second schedule u/r 25 prescribes fees for testing or analysing the samples of insecticides.

Insecticides cannot be manufactured, stored or handled with any consumable article (R IO-Q.

Packing and Labelling (R. 16 to 20):

Every container package should be of the approved type. A leaflet should be put inside containing particulars about the plant disease, insects, animals or weeds for which it is to be applied, manner of application, symptoms of poisoning, safety measures and first-aid treatment necessary, antidote, decontamination or safe disposal procedure, storage and handling precautions, effect on skin, nose eye, throat etc. and common name of the insecticide (R. 18).

In labelling, warning and cautionary statement should be included.

(1) For category-I (Extremely toxic) insecticides, the symbol of a skull and cross-bones and the word 'POISON' should be printed in red. Statement "Keep out of the reach of children and if swallowed or if symptoms of poisoning occur call physician immediately" should be added.

(2) For category II (Highly toxic) insecticides, the word TOISON' in red and statement "Keep out of the reach of children" should be printed.

(3) For category III (moderately toxic) the word 'DANGER' arid statement "Keep out of the reach of children".

(4) For category IV (Slightly toxic) the word 'CAUTION' should be mentioned.

Category classification is as under –

Classification of insecticides	Oral route (acute toxicity) LD_{50} mg/kg of test animal	Dermal route (dermal toxicity LD_{50} mg/kg of test animal.	Colour of band on the label.
Extremely toxic	1-50	1-200	Bright red
Highly toxic	51-500	201-2000	Bright yellow
Moderately toxic	501-5000	2001-20000	Bright blue
Slightly toxic	> 5000	> 20000	Bright Green

See Part 24 of Chapter-23 for pesticide industry.

Transport and Storage (R. 35, 36) :

Packages for rail transport shall be packed as per Red Tariff by Railways. No transportation or storage in such a way that insecticides may come in contact with food stuffs or animal feeds. If it is mixed up due to any damage to packages during transport or storage, it shall be examined by competent authorities notified by the State Govt. and safely disposed. If any leak occurs, the transport agency or the storage owner shall take urgent measures to prevent poisoiling and pollution of soil, water etc.

The packages of .insecticides should be stored in separate rooms or almirahs under lock and key. Such rooms shall be well built, dry, well-lit, ventilated and of sufficient dimension.

Protective Equipment and other Facilities for Workers (R. 37 to 44) :

All persons engaged in handling, dealing or otherwise coming in contact with insecticides during manufacture/formulation or spraying shall be medically examined before employment and then periodically once in a quarter by a qualified doctor who is aware of risks of pesticides and report be kept in Form XXII given below. For persons working with organophosphorous or carbamate compound, their blood cholinesterase level shall be measured monthly. The blood residue estimation shall be done yearly of persons working with organo-chlorine compound. Any person showing symptoms of poisoning shall be immediately examined and given proper treatment.

First-aid treatment shall always be given before the physician is called. IS 4015 part I and II shall be followed in addition to any other books on the subject. The workers shall be educated regarding effects of poisoning and the first-aid treatment to be given.

Protective clothing which shall be washable (to remove toxic exposure) and not allowing penetration by insecticide shall be given to workers. A complete suit shall consist (a) Protective outer garment/overalls/ hood/hat, (b) rubber gloves extending half-way up to fore-arm (c) dust-proof goggles and (d) boots.

For prevention of inhalation of toxic dusts, vapours or gases, the workers shall use (a) chemical cartridge respirator, (b) supplied air respirator . (c) demand flow type respirator (d) full or half face gas mask with canister as per requirement. In no case the exposure in air should exceed the maximum permissible level.

Sufficient stocks of first-aid tools, equipment, antidotes, medicines etc. should be kept.

The workers shall be trained for safety precautions and use of safety equipment.

The packages and surplus materials shall be safely washed and disposed to prevent pollution. The packages shall not be left outside to prevent re-use. They shall be broken and buried away from habitation.

Aerial spraying precautions are given 'in rule 43.

Form XXII : Form of Medical Examination
For the Year...........

Serial No. ………………..

Name ……………………………… Age…………..

Father's/Husband's Name ……………………… Full Address ……………………………….

Sex ……………….. Identification mark ………………………

Date of appointment ……………… Occupation : (Pleas specify the nature of duty)

PAST HIST

Illness	Poisoning	Allergy	Exposure to Pesticides (Compound)	No. of years / reasons	Remarks, if any
(1)	(2)	(3)	(4)	(5)	(6)

FAMILY HISTORY

Allergy	Psychological disorders	Gaemorhagic disorder
(1)	(2)	(3)

PERSONAL HISTORY

Smoking	Alcohol	Other addiction
(1)	(2)	(3)

OBSERVATIONS

Medical Examination	Pre-employment examination	End of 1st quarter i.e. after 3 months	After 2nd quarter i.e. after 6 months	After 3rd quarter i.e. after 9 months	End of the year	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)

I	**GENERAL EXAMINATION**		
	General body limit	Anaemia	Fatigability
	Weight	Dadema	Sweating
	Pules	Jaundice	Sleep
	Blood pressure	Skin condition	Urination
	Respiration	Temperature	
II	**GASTRO INTESTINAL**		
	Nausea	Taste	Liver
	Vomiting	Pain in abdomen	Spleen
	Appetite	Bowel movement	
III	**CARDIO RESPIRATORy**		
	Nasal discharge	Tightness of chest	Heart
	Wheeze	Dyspnoea	Cyanosis
	Cough	Palpitation	Tachycardia
	Expectoration		
IV	**NEURO MUSCULAR**		

	Headache	Tremors	Unconsciousness
	Dizziness	Convulsion	Deep reflexes
	Irritability	Paranesthesia	Superficial reflexes
	Pulse	Hallucination	Co-ordination
	Twitchings		
V	**EYE**		
	Pupil	Double vision	
	Lachrymation	Clumped vision	
VI	**PSYCHOLOGICAL**		
	Temperament	Judgement	Nervousness
VII	**KIDNEY**		
	Kidney condition		
VIII	**INVESTIGATION**		
	Blood Hb %	Serum Bilirubin	Urine microsopic
	Blood B.C.	Urine routine examination	X-ray of chest
	* Serum cholinesterase		

*Serum cholinesterase level should be measured in monthly intervals in case of organophosphorus/carbamatic group of insecticides. General remarks of the Doctor in the light of the above examination;

Advice given to : (1) the Patent : ……………………..
(2) the Employer : ……………………..

Steps taken by the Employer as per Doctor's advice

Signature/Thumb impression of:

1. Doctor:
2. Employee:
3. Employer/manufacturer:
4. Licensing officer at the time of inspection.

N.B. : In organochlorme group of insecticides the blood residue estimation should be done once a year

5. LAWS ON ATOMIC ENERGY & RADIATION :

5.1 Atomic Energy Act, 1962 :

This Act No. 33 of 1962 was passed on 15-9-1962. It has 32 sections. Its preamble says that it is an Act to provide for the development, control and use of atomic energy for the welfare of the people of India and for their peaceful purposes and for matters connected therewith. It extends to the whole of India.

Section 2 defines as under :

'Atomic energy' means energy released from process including the fission and fusion processes.

'Radiation' means Gamma rays. X-rays and rays consisting of alpha particles, beta particles, neutrons, protons and other nuclear and sub-atomic particles but not sound or radio waves or visible, infrared or ultraviolet light.

'Radioactive substance or material' means any substance or material which spontaneously emits radiation in excess of the levels prescribed by notification by the Central Government.

Outer radiation emission rate 0.1 microcurie (or inner 0.002 microcurie) per gram makes the material, legally, radioactive material.

The words fissile material, minerals, plant, prescribed equipment, prescribed substance etc. are also defined. Other provisions are as under :

1. The Central Government's powers to deal with, research into and dispose of atomic energy or radioactive substance, to dedare as 'restricted information' or 'prohibited area', to provide safety measures to prevent radiation hazards, to produce and supply electricity from atomic energy and to do all things necessary for these powers.

2. Any person discovering or suspecting uranium or thorium at: any place in India, has to report to the Govt.

3. The Central Government's power to direct any process to get uranium, under compliance or to prohibit him from doing so. Compensation may or may not be given.

4. The Central Government's power to obtain information regarding materials, plant or processes.

5. Authorised person from the Government has power to enter and inspect any mine, premises, land, plant, articles etc.

6. The Government has power to do work for discovering prescribed substances by giving a 28 days notice to the owner or occupier of the land. Compensation shall be given as per Section 21.

7. The Government's power of compulsory acquisition of rights to work minerals, of prescribed substances or equipment, plant, building, property etc. by giving notice and compensation (u/s 21) to the affected persons.

8. The Government's power to give notice to contracting parties and to transfer their rights and liabilities to the Government, of their business of mining, production or research of prescribed substances or use of atomic energy. Compensation shall be given to the parties.

9. Power of the Government to give, refuse or revoke license for mining, acquisition, production, possession, transfer, use, disposal, export or import of prescribed substances or equipment, plant for atomic energy or research. The Powers also include to make rules for the licence to follow conditions and criteria for safe location, installation or operation of the plant, for radiation protection, liability in respect of hurt to any person or property and to pay compensation for the damage, for working hours, leaves, medical examination of workers, security clearances etc., and for inspection, sealing, seizure, retention, disposal of article etc. .

10. Powers of the Government to requisite any substance and to extract uranium, plutonium or any of their isotopes from it. The compensation shall be paid for it.

11. Powers to make rules for safety of the persons or property from radiation or by the ingestion of radioactive substance, to prescribe qualifications for employment, regulation of working hours, leaves, medical examination, for safety of transport workers, for powers of authority to enter, inspect etc., any premises, vehicle, vessel, aircraft etc. and providing measures for breach of the rule, including sealing of premises, vehicle, vessel etc., and the seizure of radioactive substances and contaminated equipment.

12. The Government can order to disclosure of information and no disclose that restricted information restrict the person shall pertaining to atomic energy.

13. Power of the Government to prohibit entry of any person, without permission, into a prohibited area and taking photograph, sketch, picture, drawing, map, document etc. from there.

14. No patents to be granted for inventions relating to the use of atomic energy, even for ensuring safety in atomic energy operations. Such invention shall be reported to the Government.

15. Procedure relating to payment of compensation for the acquisition of land, property etc.

16. Power of the Central Government to develop national policy in regard to generate electricity in atomic power stations, to regulate its supply, to fix rates,, to enter into agreements with the Electricity Boards etc. and to comply with Electricity Act, 1910 and Electricity (Supply) Act, 1948.

17. The Factories Act, 1948 shall be applicable, through the Central Government, to any factory owned by the Central Government and engaged in carrying out the purposes of this Act.

18. Other provisions are relating to offences and penalties, cognisance of offences, delegation of powers to State Government or its officer etc. and rule making powers u/s 30.

5.2 Radiation Protection Rules, 1971:

The Central Government u/s 30 of the Atomic Energy Act, 1962, made these rules applicable from 3010-1971, to the whole of India. A summary of these 56 rules is, given below:

Section-2 defines adequate protection, competent authority, contamination, employer, radiation worker, operational limits, radiation installation, radiation surveillance, Radiological Safety Officer, sealed and unsealed source, source housing, useful beam etc.

Other provisions are as under :

1. Radioactive material is to be handled as per terms and conditions of a licence.
2. Luminous compounds on watches, instruments etc. are exempted.
3. No person below the age of 18 years can be employed as a radiation worker.
4. Licence can be issued on request under the Act, if the equipment, facilities and work practices afford adequate protection and if the incharge person has adequate qualification to direct the work.

   The validity of licence is 3 years. It can be revoked, modified or withdrawn by the competent authority after giving a show cause notice and an opportunity to make a representation.

   Radioactive material shall be used only for the purpose, location and quantities specified in the licence.

5. Radiological Safety Officer shall be designated by the employer (himself or an employee) with the approval of competent authority to perform following duties and functions (R. 13) :
   (1) Steps to ensure that operational limits are not exceeded.
   (2) To instruct the radiation workers about hazards of radiation and safety measures to minimise exposure to radiation and contamination.
   (3) To carry out leakage tests on sealed sources as specified in rule 34.
   (4) To regulate the safe movement of radioactive materials including waste.
   (5) To investigate and suggest remedial measures in respect of any situation that could lead to radiation hazards.
   (6) To make available' necessary reports and remedial measures to his employer.
   (7) To ensure the safe disposal of radioactive wastes in a manner approved by the competent authority.
6. Hazardous situation is to be reported to the competent authority.
7. Radiation surveillance procedure notified by the competent authority is to be followed by the employer. This may include (R. 15) :
   (1) Design, construe don, operation and use as per specifications and prior approval of the competent authority.
   (2) Working conditions, monitoring and personal protective equipment.
   (3) Personal monitoring of radiation workers.
   (4) Medical examinations of the radiation workers as per rule 19 or 20.
   (5) Records of radiation and radioactivity level measurements, personal monitoring and medical examinations stipulated by the competent authority.
   (6) Any other procedure specified by the competent authority.
8. Prior approval before any modification to the plant or any change in working conditions.
9. Radiation symbol to be displayed at workplaces and on containers containing radioactive materials. Its colour shall be as may be specified by the competent authority.
10. History records of radiation workers to be maintained in a form specified by the competent authority.
11. Pre and periodical yearly medical examinations of radiation workers, of blood, excreta, skin, hands, fingers, finger nails, eyes and chest (X-ray).

    The frequency* and types of above examinations may be modified by the competent authority where necessary (Rule 19 & 20).

    Complete records of above examinations shall be maintained. Its excerpts shall be sent to the competent authority in the form specified by him. The competent authority shall preserve such records for the life time of the worker or for 20 years after he ceases to do work of radiation, whichever is shorter.
12. The competent authority may specify steps to reduce the excessive exposure and the employer shall comply with them and also provide the exposed worker an alternative work not involving radiation exposure. If such worker is declared fit to resume radiation work, his employer shall permit him to do that work. Then his work shall be planned by the competent authority.
13. The competent authority or a person duly authorised by him has wide power to inspect new, modified or running radiation installation, work being conducted, protective device, transport etc. and make tests, measurements and other things to verify adequate protection.

    Power includes power to seal or seize radioactive material or equipment and give directions for compliance.
14. Registers of particulars of sealed and unsealed sources shall be maintained (Rule 33).
15. In case of leakage of a sealed source, the Radiological Safety Officer shall place that leaking source in a properly shielded leak-proof container with care to prevent spread of contamination, act to safeguard the workers and others, vacate affected area, clean up contamination if any, and inform the employer.

16. Lost or missed radioactive material shall be searched and the competent authority shall be informed immediately.
17. Telegamma sources shall be covered with appropriate source housing. In case of power failure, the useful beam should be automatically cut off. Manual device to interrupt the useful beam is required (Rule 37 to 39).
18. In medical institutions where radioactive material remains on or inside the body of the patient, separate rooms and wards for the treatment shall be provided.
19. Where gamma radiography is done, the area shall be cordoned off to control entry into it of other persons.
20. Sealed source devices such as static eliminators, thickness, density or level gauges, package monitors shall be provided with efficient cover plate, shutter or shield capable of being easily operateable to attenuate the useful beam.
21. Interlock switches in radiation installations should be of the fail-safe type.
22. Unsealed sources shall be kept in securely closed container and properly labelled.

    Radiological Safety Officer has to take more precautions where unsealed sources are handled such as safe working methods, facilities to minimise radiation level and airborne contamination, forbidding wrong working habits (mouth operated devices, open wounds, smoking, eating, drinking, application of cosmetics etc.), appropriate protective clothing, safe use of PPE and checking contamination on it and safe collection of radioactive wastes .(R.44 & 45).
23. Ventilating systems should be enclosed with ducts and filters to avoid spread of any airborne contamination.
24. In case of spillage, steps to arrange decontamination of affected personnel and areas, steps to prevent further spread of contamination and informing the employer.
25. Other provisions for experiments on animals, luminising compounds, approved procedure for mining, processing etc., disposal of animal carcasses, autopsies of cadavers, licence, personnel monitoring and power to exempt are given in rules 48 to 56.

Notes on Regulatory Aspects

Radioisotopes and radiation have found a variety of applications in industries, such as non-destructive testing, level indication system, thickness gauges, density gauges, etc. There are over 1200 industrial institutions in India, employing radiation source, in one form or the other. It is a well known fact, that ionising radiation such as X-rays, gamma rays, beta rays, etc. are deleterious to health. It is therefore, essential to minimise radiation exposures to the user as well as to the public. If the use of these radiation sources is not adequately controlled, it is likely to result in unnecessary radiation exposures to individuals. However, if necessary safety precautions, as per the stipulated norms, are observed by the user, the ill-effects of radiation can be minimised, thus, rendering the application quite safe for the user.

The prospective user should approach the Competent Authority for obtaining permission to handle radiation sources. He must give the requisite details in the prescribed application form regarding the type of source, its activity, proposed use, name of the. user, his qualification and experience in the handling of radiation sources, etc.

A precommissioning inspection of the installation is properly done by members of Radiation Protection Services Division (RPSD), Bhabha Atomic Research Centre (BARC), Bombay-400 085, in order to confirm the above.

A separate storage enclosure should be available at the site for safe storage of the source housings, prior to their installation and also to store, spare source housings and decommissioned gauges awaiting ultimate disposal, if any. The source storage should be so chosen, that it would be free -from potential fire hazard, flooding, water logging, pilferage etc. Advice on the nature of storage facility required may be obtained from the Competent Authority.

All the persons who are involved in the operation and maintenance of these gauges, should have adequate knowledge' in the design, construction and principle of the gauges and they should have undergone appropriate training on the radiation safety aspects. Further, if deemed necessary, all those persons who are involved in the maintenance of radioisotope gauge may have to be monitored regularly, by the personal monitoring service, run by RPSD, in order to, ensure that dose limits are not exceeded. The decision regarding the need for the persons to be monitored by the personnel monitoring service will be taken after the precommissioning inspection of the installation by members of RSPD.

A GM type radiation survey meter (model MR 121) manufactured by the Electronic Corporation of India Ltd. (ECIL), Hyderabad or its equivalent should be available with the user of the nucleonic gauges, for regular monitoring of radiation levels around the gauge installation and also for deciding the area to be cordoned off around the source, if an emergency arises.

The user should designate a Radiological Safety Officer, who possesses a certificate in radiation safety which is recognised by RPSD and who has received instructions in the Radiation Protection, Rules 1971 and all notifications and orders issued there under, relevant to the proposed application of radiation and who has demonstrated competence in the handling of radiation exposure devices and related instruments and radiation survey meters, which would be used in the course of this assignment. Formal approval should be obtained by the user, from the Competent Authority, for the appointment of Radiological Safety Officer.

The requisite authorisation for the procurement of nucleonic gauges from any Indian manufacturer or the requisite 'No Objection Certificate' for the import of nucleonic gauges of specific type from abroad will be issued by the Competent Authority after the fulfilment of the above requirements by the applicant. All these regulatory controls have been evolved, in order to ensure safety to persons and property, during the use of these gauges.

6. LAWS ON TRANSPORTATION SAFETY :.

6.1 Motor Vehicles Act, 1988 :

Replacing the Act of 1939, this Act (59 of 1988) came into force from 1-7-1989. It was amended in 1994. It extends to the whole of India. It has 14 Chapters, 217 sections and 2 schedules.

Statement of objects and Reasons:

The 1994 Act inter alia provides for

1. Definitions of new type of vehicles.
2. Simplification of procedure to grant a driving licence.
3. Restrictions on alteration of vehicles.
4. Exemptions for non-polluting vehicles.
5. Ceilings removed to curb benami holdings.
6. States .can appoint ST Appellate Tribunals.
7. Punitive checks on substandard components and stocking/sale by the traders.
8. Increase in compensation amount.
9. Removal of time limit for filling claims.
10. Certain punishments made stringent.

11. New formula for compensation based oil age income.
12. The Law .Commission's recommendation regarding claim jurisdiction incorporated.

Definitions : In 49 definitions, new definitions of 'manufacturer' (of motor vehicles) and local authority as ST undertaking are added. Heavy goods means more than 12 Tonnes weight. Light motor vehicle should not exceed 7.5 tonnes. Vehicle having less than 25 CC engine capacity is not a motor vehicle.

Motor vehicle or vehicle means any mechenically propelled vehicle adapted for use upon roads whether the power of propulsion is transmitted thereto from an external or internal source and includes chassis to which a body has not been attached and trailer, but does not include a vehicle running upon fixed rails or a vehicle of a special type adapted for use only in a factory or any other enclosed premises or a vehicle having less than 4 wheels fitted with engine capacity of not exceeding 25 cc.

Licensing of Drivers (Chapter 2, Sec. 3 to 28) :

Without licence no person can drive a motor vehicle. Age limit require to drive a motor cycle of capacity less than 50 CC is 16 years, to drive a transport vehicle it is 20 years and in other cases it is 18 years. For breach the owner of the vehicle, is responsible. The licence is non-transferable. (S. 3 to 7).

Procedure for application and grant of licence is given u/s 8 to II. Matters of licensing and regulation of driving schools are given in Sec. 12. Driving licence is effective throughout India (S. 13). Renewal procedure is given u/s 15, revocation on ground of disease or disability u/s 16 and appeals u/s 17. Grounds of disqualification (drunkard, addict, criminal, fraud, nuisance or danger to public) and revocation are given u/s 19.

Currency of licence u/s 4 is as under :

1	Learner's license	6 months
2	Licence to drive transport vehicle	3 years
3	Licence to drive transport vehicle carrying dangerous goods and renewal with condition to undergo 1 day refresher course of the prescribed syllabus.	1 year.
4	Any other case	20 years or age of 50 years whichever is earlier.
5	After the age of 50 years	5 years
6	After the date of expiry of licence	1 month.

Other provisions are as under :

Power of Court to disqualify	Sec. 20
Suspension of driving licence	Sec. 21, 22
Effects of disqualification	Sec. 23
Endorsement and transfer	Sec. 24, 25
State Register of driving licences	Sec. 26
Rule making power of Central Govt.	Sec. 27
Rule making power of State Govt.	Sec. 28

Others:

Chapter-3	Licensing of Conductors
Chapter-4	Registration of Motor vehicles

Chapter-5	Control of Transport vehicles
Chapter-6	ST undertakings
Chapter-7	Construction, Equipment and Maintenance of motor vehicles.
Chapter-8	Control of Traffic
Chapter-9	Vehicles temporarily leaving or visiting India.
Chapter-10	Liability without fault.
Chapter-11	Third party risk insurance
Chapter-12	Claims tribunals
Chapter-13	Offences, penalties and procedure.
Chapter-14	Miscellaneous
Chapter-15	Traffic Signs
Schedule -2	Compensation of third party claims.

Construction & Maintenance of Vehicles (Chap. 7):

Control of the vehicle should remain effective. Right hand steering is required unless it is equipped with a mechanical or electrical signalling device of a prescribed nature (S. 109).

Central Government can make rules on the following matters

1. Width, height, length, overhead of vehicles and loads to be carried.
2. Size, nature, price, and condition of tyres and marking of date of manufacture and maximum load carrying capacity.
3. Brakes and steering' gear.
4. Safety glasses including prohibition of tinted safety glasses.
5, Signalling appliances, lamps & reflector.
6. Speed governors.
7. Emission of smoke, visible vapour, sparks, ashes, grit or oil.
8. Chassis number, engine number and date of manufacture.
9. Safety belts, handle bars of motor cycles, autodippers and other equipment essential for safety of drivers, passengers and other road users.
10. Standards of components used as in-built safety devices.
11. Transport of dangerous goods.
12. Standard for emission of air pollutants.
13. Installation of catalytic converters.
14. Placement of audio-visual or radio or tape recorder etc. in public vehicles.
15. Warranty after sale and norms therefore.

Exemption can be given subject to conditions (S.IIO).

State Governments can make rules on the above matters and on the following matters also

1. Seating arrangements in public service vehicles and protection from weather.
2. Prohibiting or restricting the use of audible signals at certain times .or in certain places.
3. Prohibiting the carrying of appliances to cause annoyance or danger.
4. Periodical testing and inspection and fees to be charged.
5. Use of trailers with motor vehicles.
6. Particulars to be exhibited.

Control of Traffic (Chap. 8) :

Following provisions are made -

1. Limits of speed, maximum &: minimum (S. 112).
2. Limits of weight and use (S. 113).
3. Requiring the .vehicle to be weighed. (S. 114).
4. Restriction on use of vehicles (S. 115).
5. Requiring erection of traffic .signs (S. 116).
6. Parking places and halting stations (S. 117).
7. Driving regulations (S. 118).
8. Duty to obey traffic signs (S. 119).
9. No left hand driving in public place (S. 120).
10. Signals and signalling devices (S. 121).
11. Leaving vehicle in dangerous position (S. 122).
12. Not to travel on running board, top bonnet or body of the vehicle (S. 123).
13. Prohibition to travel -without pass or ticket (S. 124).
14. Obstruction of driver (S. 125).
15. Stationary vehicles (S. 126).
16. Removal of vehicles abandoned or left unattended on a public place (S. 127).
17. Safety measures for drivers and pillion riders. No driver will carry more than one person on a two wheeler. (S. 128).
18. Wearing helmet confirming to IS, while driving motor cycle. A Sikh's turban is exempted. (S. 129).
19. Duty to produce licence and certificate of registration. Police Officer in uniform can demand a driving licence. RTO can demand insurance certificate, fitness certificate, permit and a conductor's licence (S. 130).
20. Precautions at unguarded railway level crossings. Ensure that no train or trolley is approaching from either side (S. 131).
21. Duty to stop in certain cases like accident to a person, vehicle, property or animal (means horse, cattle, elephant, camel, ass, mule, sheep or goat) (S. 132).
22. Duty of owner to give information regarding driver to a police officer (S. 133).
23. Duty of driver in case of accident and injury to a person. He will carry unless it is not practicable due to mob fury, the injured person to the nearest doctor or hospital who will immediately attend without waiting for any procedural formalities unless the injured person desires otherwise. He will also give information to a police officer and the insurer (S.134).
24. The State Government can make schemes for investigation of accident cases and wayside amenities (S. 135).
25. Inspection of vehicle involved in accident (S. 136).
26. Rule making power of the Central Govt. (S. 137).
27. Rule making power of the State Govt. (S. 138).

6.2 Central Motor Vehicles Rules, 1989 (including Rules pertaining to Transport of Hazardous Goods) :

Under the Motor Vehicles Act, 1988, these Central Motor Vehicles Rules, 1989 were notified on 2-6-1989. They came into force from 1-7-1989 save as otherwise provided in rule 1(3). They were amended in 1993, for transportation of hazardous materials vide Notification dated 26-3-1993, New Delhi. Amendment also came on 28-3-2001.

In Chapter-5 (Construction, Equipment and Maintenance of Motor Vehicles) Rule No. 91, 92 and 129 to 137 are pertaining to transport of dangerous or hazardous goods and their abstract is given belfflu.

Definitions (R. 91) :

'Dangerous or hazardous goods' means the goods of dangerous or hazardous nature to human life specified in Table I, II and III to Rule 137.

Consignor means the owner of hazardous goods.

Emergency information penal means the penal specified in rule 134.

Primary risk is the most potent risk and subsidiary risk is in' addition to that.

General (R. 92):

A motor vehicle including construction equipment vehicle shall be used or allowed to be used in a public place in compliance with this chapter. If the vehicle does not remain under effective control it shall not be used except by towing.

Class Labels, Safety Equipment & Tachograph (R. 129):

Every owner shall display on goods carriage and on every package mark of class label specified in Table I to Rule 137. If the package represents two hazards given in Table III to rule 137, two labels shall be displayed on the package. The label on the package should be appropriate to the type of hazardous goods as specified in Table to Rule 137. Such goods carriage shall carry safety equipment to prevent fire, explosion or escape of hazardous goods and shall be fitted with tachograph conforming to IS, to record the lapse of running time of the motor vehicle, time speeds maintained, acceleration, decceleration etc.

Spark Arrester (Rule 129A) :

Goods carriage carrying dangerous or hazardous goods to human life, shall be fitted with a spark arrester.

Manner of Display of Class labels (R. 130) :

Size of class label on a goods package (e.g. box, drum etc.) should be more than 25 I1lm2 and display angle 45°. Adhesive material should be waterproof. It should not obscure any other markings necessary. On front and rear both the sides it should be displayed.

Consignor's duty (R. 131) :

Every consignor shall supply to the owner of the goods carriage accurate and sufficient information about the hazardous goods so as to enable such owner and his driver to comply with Rules 129 to 137 and be aware of the risk to the health or safety of any person.

Valid registration to carry hazardous goods listed in Table-111, first aid, safety equipment, antidote; training to driver to control transport emergency are also necessary.

Carriage Owner & Driver's duty (R. 132) :

They will satisfy themselves about the information given to them by the consignor. The driver will b given .relevant information in Annexure-V which will be kept in the driver's cabin and available during transportation.

Valid registration to carry hazardous goods, firs aid, safety equipment, tool box, antidotes, fixing of trip route and valid driving licence are also necessary.

Driver to take precautions (R. 133) :

Driver 'shall observe at all times all the precautions to prevent fire, explosion or escape o hazardous goods, shall ensure parking in a safe place and under control and supervision of himself or some other competent person above the age of 18 years. The driver will keep a TREMCARD and information u/ 132(3) in his cabin.

Emergency information Penal (R. 134) :

Such panel (marked on goods carriage i.e. vehicle shall contain -

1. The correct technical name of the hazardous goods in letters bigger than 50 mm size.
2. Class label of more than 260 mm^2 size.
3. Telephone number of emergency services to I contacted in case of fire or any accident with letters and numbers of more than 50 mm size an also the name and telephone number of consignor or other person to receive advice c emergency measures.
4. A sticker on vehicle showing goods being carried on in that trip.

See fig. 28.1 for dimensions of "Emergency Information Panel" and fig. 28.2 for its placement on goods carriage.

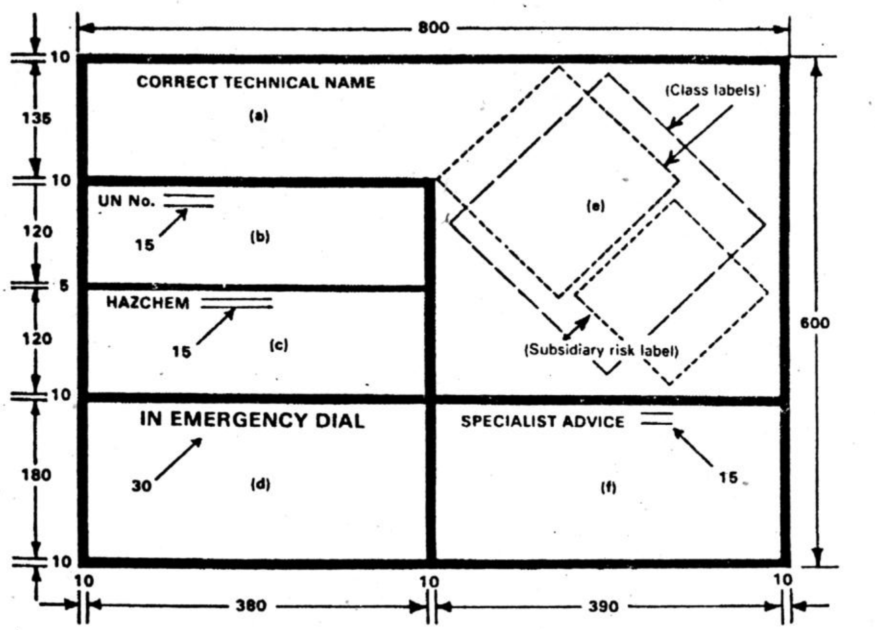


Fig. 28.1 Dimensions (all in mm) of emergency information panel.

EMERGENCY INFORMATION PANELS

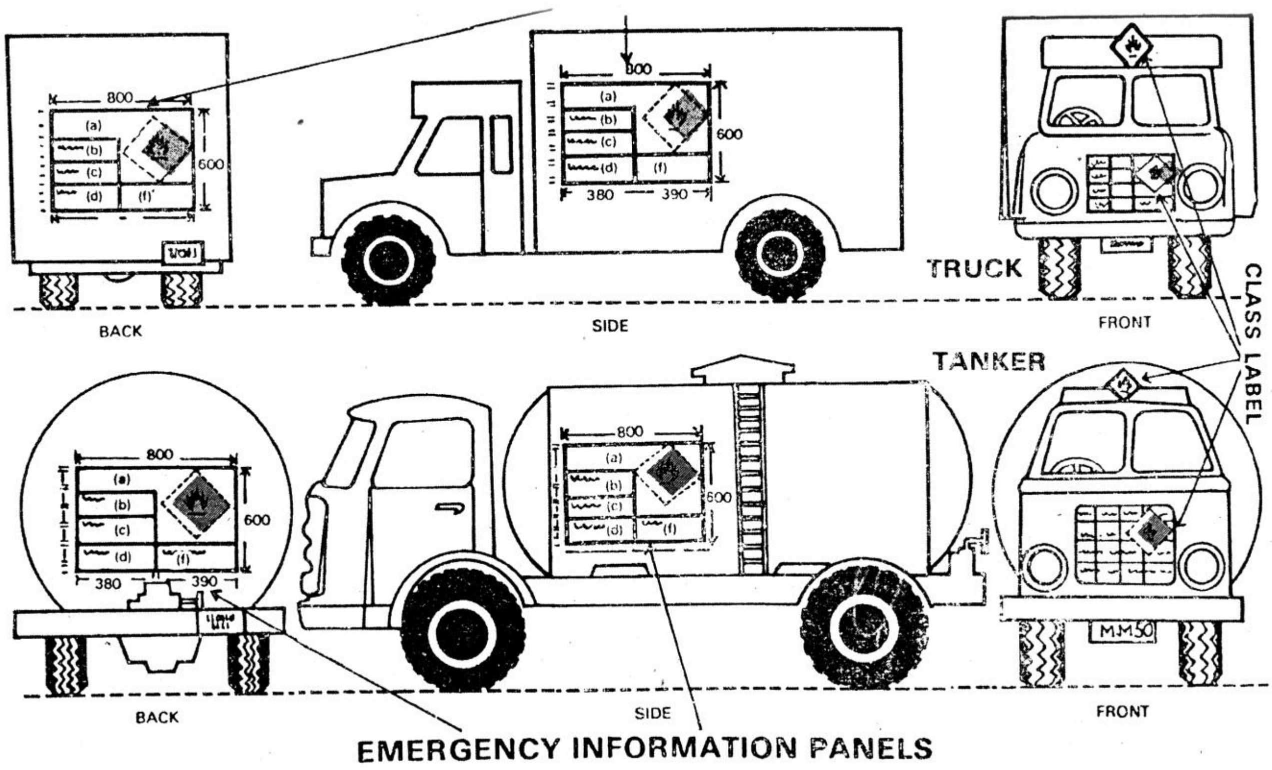


Fig. 28.2 Placement of Emergency Information Panels on goods carriage.

Driver to be instructed (R. 135) :

The owner of goods carriage shall ensure the satisfaction of the consignor that the driver has received adequate instructions and training to understand -

1. Nature of the goods.
2. Nature of the risks there from.
3. Precautions while driving or parking.
4. Action to be taken in case of emergency.

Report of Accident (R. 136) :

The driver transporting any hazardous goods shall forthwith report any accident involving such goods to the nearest police station and also the owner of the goods carriage or the transporter.

Class Labels (R. 137) :

See Table I for eight types of Class Label for Hazardous Goods

Table -1 : Eight 'Class Labels' for Hazardous Goods

Class No.	Type of Goods	Class Label		
		Symbol	**Colour of Symbol**	**Colour of Background**
1 1.1 1.2 1.3 1.4 1.5	Explosives “ “ “ “ “		Black	Orange
2	(1) Non-flammable compressed gases		Black or White	Green
	(2) Flammable gas		Black or White	Red
	(3) Poison (Toxic) gases		Black	White
3	Flammable liquids		Black or White	Red

4 4.1	Flammable Solids		Black	White with vertical red strips
4.2	Substances liable to spontaneous combustion	 Black	Upper half white, lower half red	
4.3	Substances which, in contact with water, emit flammable gases		Black or White	Blue
5 5.1	Oxidising substances		Black	Yellow
5.2	Organic Peroxides		Black	Yellow

6 6.1	(1) Poisonous (toxic) substances		Black	White
	OR (2) Harmful, poisonous (toxic) substances, away from foodstuffs		Black	White
6.2	Infectious substances		Black	White
7	Radioactive substances		Black	Top half yellow, bottom half white
8	Corrosives	 Black	Upper half white, lower half Black with white border	

Table - II : Indicative Criteria :

(a) Toxic chemicals :
1. Oral in rats LD,, > 5 to 200 mg/kg.
2. Cutaneous in rats or rabbits LD, = 10 to 400 mg/kg.
3. Inhalation (4 hrs) in rats LC, == O.I to 2% mg/l

(b) Flammable chemicals :
1. Flammable Gases BP = 20°C at normal pressure.
2. Highly flammable liquids - BP> 20°C at normal pressure and FP< 21°C.
3. Flammable liquids - FP < 55°C and which remain liquid under pressure.

(c) Explosives - Chemicals which may explode under the effect of flame or whidi are more sensitive to shocks or friction than dinitrobenzene.

Table - III : List of Hazardous & Toxic Chemicals;

Chemicals are listed and classified as

C = corrosive, E = Explosive, F = Flammable,
O = Oxidising, R = Reactive and T = Toxic

For the details the list should be referred.

IS:1446 gives classification of dangerous goods and classifies risks, subrisks, chemical substances and dangerous goods.

7. LAWS ON CONSTRUCTION SAFETY :

7.1 Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996;

This Act (No. 27 of 1996) came into force from 1-3-1996. It extends to the whole of India,. The Act has II chapters and 64 sections.

Preamble : It states that this Act is to regulate the employment and conditions of service of building and other construction workers and to provide for their safety, health and welfare measures and for other matters connected therewith or incidental thereto.

Amenability : The Act applies to every establishment (an individual, firm, association, company, contractor. Government etc.) which employs or had employed on any day of past one year ten or more building workers in any building or other construction work.

It does not apply to an individual who constructs his own residence costing less than Rs. 10 lakhs.

Definitions : Section 2 defines appropriate government (means Central or State Govt), Board, building or other construction work, building worker, Chief Inspector, Director-General, employer (Govt authority, contractor), establishment, fund, wages etc.

Scope : The' Act has chapters on advisory and expert committees, registration of establishments and building workers as beneficiaries, welfare boards, working hours, welfare and other conditions, safety and health measures, inspecting staff, special provisions, penalties (max. Rs. 2000 or 3 months or both) and procedure and miscellaneous.

Welfare : Powers are given to the States to constitute a Welfare Board and the Central/State Government can make rules for prescribing working hours, intervals, rest day, double wages if worked on rest day, overtime wages at twice the ordinary wages, records & registers, latrines & urinals for more than 50 workers, temporary living accommodation (free of charge) which shall be removed or demolished after the work is over, first aid and canteen facilities for employing more 'than 250 workers.

The Act prohibits to employ person who is deaf or has a defective vision or a tendency to giddiness to avoid accident,

The Act provides for drinking water points situated 6 mt. away from any washing place, urinal or latrine, and creche rooms for more than 50 female workers for their children under the age of six years.

Safety and Health Measures (Chapter 7, Sec. 3841):

They are as under :

1. For 500 or more workers. Safety Committee is necessary.
2. For 500 or more workers qualified Safety Officer is necessary.
3. Notice of accident is required for disablement of more than 48 hours. If 5 or more persons die, inquiry within one month is required.
4. Central/State Government has power to make rules pertaining to
   (1) Scaffolding at various stages, means of support and safe means of access.
   (2) Precautions while demolition, shoring etc.
   (3) Competent person to control hazards of explosion or flying material.
   (4) Competent persons to drive or operate transport equipment such as locomotives, trucks, wagons, cranes , trailers, etc.
   (5) Hoists, lifts, lifting gear, their testing, heat treatment and precautions while raising or lowering loads etc. and requirement of competent persons.
   (6) Sufficient .and suitable lighting.
   (7) Adequate ventilation at work place, confined space and prevention of dust, fumes, gases, vapours etc.
   (8) Precautions while stacking, unstacking, stowing, unstowing and handling of materials or goods.
   (9) Safeguarding of- machinery.
   (10) Safe handling and use of pneumatic tools, equipment, etc.
   (11) Fire precautions.
   (12) Maximum weight to be lifted or moved.
   (13) Safety of workers while transporting them by water and their rescue from drowning.
   (14) Safety of workers from live electric wires, overhead wires and electrical machinery, apparatus and tools.
   (15) Safety nets, safety sheets and safety belts as per need.
   (16) Standards of compliance with regard to scaffolding, ladders, stairs, lifting appliances, ropes, chains, & accessories, earth moving equipment and floating operational equipment.
   (17) Precautions while pile driving, concrete work, work with hot asphalt, tar etc. insulation work, demolition, excavation, underground construction and handling materials.
   (18) Safety policy.
   (19) Information of Bureau of Indian Standards under the Bureau of Indian Standards Act, 1986, (63 of 1986). regarding use of any articles or process covered under that Act.

(20) Medical facilities for building workers.
(21) Any matter concerning the safety and health of building/construction workers.

5 The Central Government may frame model rules in respect .of matters stated above which shall be followed by the State while making their rules.

Inspection Staff (Chapter-8, S.42,43) : The Central Govt. may appoint the Director-General of Inspection and the State Govt may appoint the Chief Inspector of Inspection of Building and Construction and both the Governments may appoint necessary Inspectors for local limits. All such Inspectors are public servants u/ s 21 of the IPC. Any document or information shall be produced to the Inspector u/s 175 & 176 of the IPC, and Sec. 94 of the Cr. P. C. is also applicable for the power of search & seizure. Wide powers are prescribed u/s 43 for the Inspectors.

Special Provisions (Chapter-9, S.44 to 46) : An employer is responsible to provide constant and adequate supervision to prevent accidents and to comply safety provisions under this Act (S.44), to pay wages and compensation to building workers (S.45) and to give notice of commencement of building or other construction work at least 30 days before to the Inspector concerned (S.46).

Next Chapter-10 (S.47 to 51) provides for penalties and procedure and Chapter-11 (S.56 to 64) for delegation of powers, returns, protection of action taken in good faith and power' of Central Government to give directions, to remove difficulties and to make rules.

The Building and other Construction Workers" Welfare Cess Act, 1996 (No. 28 of 1996), received the assent of the President on 19-8-1996 and came into force from 3-11-1995. An employer is required to pay cess more than 1% but less than 2% of the cost of construction for the purposes of the Act No. 27 of 1996. The local authority or the State Government can collect the cess in advance while giving approval of a building or construction and shall pay to the Board after deducting the cost of collection not exceeding 1% of the amount collected. Late payment interest is 2% per month on the unpaid amount and a penalty not exceeding the amount of cess is also chargeable after giving opportunity to be heard.

7:2 Building and other Construction Workers (Regulation of Employment and Conditions of Service) Central Rules, 1998:

U/s. 62 and Sec. 40 of the Act (previous Part 7.1), the Central Government made these rules. They came into force from 19-11-1998.

They apply to the work under the jurisdiction of the central Government. They have 5 parts, 30 chapters, 252 rules, 12 schedules and 26 forms. Section-2 gives 74 definitions most of which are technical terms. Thus these rules are very exhaustive and contain many technical details.

Partwise subject division is as under :

Part I	Preliminary, Chap I, II, R. I to 9.
Part II	Central Advisory Committee, Registration of Establishments, Chap III to V, R. 10 to 33.
Part III	Safety & Health, Chap VI to XXV, R. 34 to 233.
Part IV	Hours of work. Welfare, Payment of Wages, Registers & Records etc.. Chap XXVI to XXIX, R. 234 to 249.
Part V	Miscellaneous provisions. Chap XXX, R. 250 to 252.

Thus out of 252 rules, 200 are pertaining to Safety & Health and mostly require engineering knowledge.

Chapter wise subject matter is as under :

Chapter-1 Preliminary (R. I to 4) :

Short title, application, commencement, definitions, interpretation of words not defined and savings.

Chapter-11 Responsibilities and Duties of Employers, Architects, Project engineers & Designers, Building workers etc. (R. 5 to 9):

Rule 5 pertaining to duties of employer and Rule 8 regarding duties of workers are important They have to comply with the provisions of these rules, maintain lifting appliance, transport equipment and all safety devices conforming to safety standards, testing etc., discover and report defects if any, not to remove or interfere with fencing, gangway, gear, ladder, life saving appliances etc., to use only safe means of access and to keep latrines, urinals, washing facilities and canteen in clean and hygienic condition.

Chapter-111 Central Advisory Committee (R. 10 to 22):

Constitution of the Committee, terms of office, membership, staff, meetings, quorum etc. are prescribed.

Chapter-IV Registration of Establishment (R. 23 to 27):

Application for registration in triplicate in Form1, with fees (by DD) to the Registering Officer, grant of certificate of registration (Form-11), Register of Registration (Form-111), and conditions of registration. Fees as under :

Building workers upto 100	-	Rs. 100
101 to 500	-	Rs. 500
501 and more	-	Rs. 1000

Chapter-V Appeals, Copies of Orders, Payment of Fees, etc. (R. 28 to 33) :

Appeal and hearing procedure is prescribed. All fees are to be paid by a crossed DD.

Chapter-VI Safety & Health, General Provisions (R. 34 to 54):

Noise level within limits (Sch. VI), fire protection, emergency action plan for site employing more than 500 workers, fencing of machinery, manual lifting within limits (adult man 55 kg, adult woman or adolescent male 30 kg and adolescent female 20 kg), Health & Safety policy for employing 50 or more workers. Carbon monoxide below 50 ppm and removal of hazardous dust, gas, fumes and oxygen deficiency from any confined space, overhead protection for a building under construction of 15 mt or more in height, the width of protection should be more than 2 mt and height less than 5 mt above the base of the building, protection against slipping, tripping, cutting, drowning and falling hazards, safety net and other adequate equipment to prevent fall, PPE for protection of eye, head and safety from corrosive chemicals, control of electrical hazards, vehicular traffic, stability of structures, illumination of passageways, stacking of materials, disposal of debris, numbering and marking of floors and use of safety helmets and shoes conforming to IS.

Chapter-VII Lifting Appliances and Gear (R. 55 to 81):

All lifting appliances including their parts and working gear, whether fixed or movable should be of sound construction, sound material, adequate strength and maintained in good repair and working condition (R. 55). Provisions for test and examination by a competent person at every 5 years in the manner specified in Sch. I, automatic safe load indicators, safe installation, winches, buckets, safe working load, loading safely and within SWL, operator's cabin, operating instructions, hoists, fencing, rigging of derricks, securing of derrick foot, yearly examination of lifting gears, ropes, heat treatment, register of testing (Form V to X and XXVI), vacuum and magnetic lifting gear, knotting of chains & wire ropes, carrying of persons, attachment of loads, tower cranes and qualification of operator are also prescribed.

Chapter-VIII Runways and Ramps (R. 82 to 85):

Runways or ramps to be used by building workers should have width more than 43 cm, plank thickness 2.5 cm or more, open sides above 3 mt should have guard rail of I mt height and sufficient strength. Runway or ramp to be used by transport equipment should have a width more than 37 mt with timber curbs of 20 cm x 20 cm in width and placed parallel to and secured to the sides of such runway or ramp. Slop of ramps less than I in 4, continuous rise less than 3.7 mt and no more rise without broken by horizontal landing of length 1.2 mt or more. Runway or ramp to be used for wheel-barrows, hand carts or hand trucks should have width more than a metre with plank thickness more than 5 cm.

Chapter-IX Work on or adjacent to Water (R. 86, 87):

Water transport vessel with responsible person, life buoys on deck, prevention from drowning by fencing and suitable rescue equipment etc. are prescribed.

Chapter-X Transport and Earth moving equipment (R. 88 to 95) :

They should be of sound construction and sufficiently strong for the purpose, of sufficient size, duly certified, inspected weekly and safe carrying capacity marked. Power trucks and tractors with effective brakes, head lights, tail lamps, tie chains etc.

Power shovels and excavators, bulldozers, scrappers, mobile asphalt layers and finishers, pavers and road rollers should have silencers, tail lights, power and hand brakes, reversing alarm and search light for forward and backward movement. Pavers should have guards to prevent workers walking under their skip. While moving downhill the engine should be in gear. Open light is not permitted to see level of asphalt. Load bearing capacity of the ground should be examined before using a road roller.

Chapter-XI Concrete Work (R. 96 to 107) :

In addition to general provisions regarding use of concrete, specific safety and health provisions are prescribed for preparation and pouring, erection of concrete structures, buckets, pipes & pumps, mixing and " pouring of concrete, panels & slabs, stressed and tensioned elements, vibrators, inspection & supervision, beams, floors and roofs, stripping and re-shoring.

Chapter-XII Demolition (R. 108 to 118) :

Provisions are made for preparation before demolition, protection of adjacent structures, demolition of walls, partitions etc., method of operation, access to floor, demolition of structural steel, storage of material, floor openings, inspection, warning signs, barricades and mechanical methods of demolition (i.e. by swinging weight, clamshell bucket, power shovel, bulldozer etc.).

Chapter-XIII Evacuation and Tunnelling Works (R. 119 to 168) :

Subjects prescribed are notification of intention to carry out such work, project engineer, responsible person, warning signs and notices, register of employment, illumination, stability of structure; pilling, shoring & bracing, safe access, trenches, depth of trenches, positioning and use of machinery, breathing apparatus, safety measures for tunnelling operation, pneumatic tools, shafts, lift for shaft, means of communication, signals, clearances, shelters, use of internal combustion engine, inflammable oils, coupling and hoses, hose installation, fire resistant hoses, flameproof equipment, storing of oil and fuel underground, use of gases underground, water for fire fighting, flooding, steel curtains, rest shelters, permissible limit of exposure of chemicals (Sch. XII), ventilation, air supply intake point, emergency generators, air mains, bulk head and air-locks, diaphragms, portable electric hand tools (upto 24 volts), circuit breaker, transformer, live wires, welding sets, quality and quantity of air (more than 0.3 m3/ min/person), working temperature (less than 29"C), man-locks and working in compressed air environment, safety instruction and medical lock.

Chapter-XIV Steep Roof (R. 169 to 171):

Safety measures are prescribed for work on steep roofs, construction and installation of roofing brackets and crawling boards.

Chapter-XV Ladders & Step-ladders (R. 172 to 174):

Provisions are made for their construction and safe use, rungs and materials.

Chapter-XVI Catch platform and Hoarding, Chutes, Safety belts & Nets (R. 175 to 180) :

Provisions are made for catch platforms (minimum width 2 mt, inclined height 1.5 mt and open end with fencing of 1 mt height), hoarding for protection of workers, chutes and its use, safety belts, • nets, their use and storage.

Chapter-XVII Structural Frame & Frame work (R. 181 to 185) :

Provisions are made for trained workers for erection of structural-frame and framework, formwork, false work, shoring and deshoring, erection and dismantling of steel and prefabricated structure.

Chapter-XVIII Stacking & Unstacking (R. 186, 187) :

This should be in a safe way, on firm foundation, not against weak partition or wall, safe means of access for a height above 1.5 mt, under supervision, 10 cement (lime etc.) bags in a pile and adequate support for more height, storing of cement or lime in dry place, bricks, tiles or blocks on firm ground, steel according to its shape, size and length and at the lowest level, pipe should not fall by rolling, angle of repose (See Table-21 of Chapter32) of loose materials to be maintained and dust mask for handling of dust laden material.

Chapter-XIX Scaffold (R. 188 to 205) :

Provisions are made for scaffold construction (bamboo or metal), supervision by a responsible person, maintenance, standards, ledger, putlogs, working platform, board, plank and decking, repair of damaged scaffold, opening, guardrails, scaffold used by building workers of different employers, protection against electric power line, screening net and wire nets, tower scaffold, gear for suspension of scaffold, trestle scaffold and cantilever scaffold, scaffold supported by building, use of winches and climbers for suspended scaffold and safety devices for suspended scaffold.

Chapter-XX Cofferdams and Caissons (R. 206,207):

These should be of good construction, sound material, of adequate strength and inspected by a responsible person. Safe means of access, work under supervision and work in compressed air as per standard laid down procedure. Pressure plant and equipment should be examined by a competent person and maintained in good repairs and working condition. Safety valve, pressure gauge (dial range within 1.5 to 2 times the maximum working pressure) and stop or isolation valve are also necessary.

Chapter-XXI Safety Organisation (R: 208 to 211):

Safety Conimittee is necessary where 500 or more building workers work. Equal number of members from employer and employees. Meeting monthly. Senior person having overall control over the affairs of the construction site should be the chairman. Main function prescribed. Agenda and minutes should be circulated and shown to the Inspector on demand.

Safety Officer is necessary where 500 or more building workers work. Their number, qualification, condition of service (including status and scale), duties and facilities are prescribed in Sch. VIII. Requirement of Safety officers is as under :

Up to 1000 building workers	-	1 Safety Officer
Up to 2000	-	2 Safety Officer
Up to 5000	-	3 Safety Officer
Up to 10000	-	4 Safety Officer

For every additional 5000 workers, one more safety officer is required.

Qualification required is B.E., B. Tech or B. Arch with 2 years experience or Diploma holder with 5 years experience and a degree or diploma in industrial safety with an elective subject of construction safety. Other experience is also prescribed. Their duties are reproduced below from Sch. VIII.

(i) to advise the building workers in planning and organising measures necessary for effective control of personal injuries;

(ii) to advise on safety aspects in a building or other construction work and to carry out detailed safety studies of selected activities;

(iii) to check and evaluate the effectiveness of action taken or proposed to be taken to prevent personal injuries;

(iv) to advise purchasing and ensuring quality of personal protective equipment confirming to national standards;

(v) to carry out safety inspections of building or other construction work in order to observe the physical conditions of work, the work practices and procedures followed by building workers and to render advice on measures to be adopted for removing unsafe physical conditions and preventing unsafe actions by building workers;

(vi) to investigate all fatal and other selected accidents;

(vii) to investigate the cases of occupational diseases contracted and reportable dangerous occurrences;

(viii) to advise on the maintenance of such records as are necessary with regard to accidents, dangerous occurrence and occupational diseases;

(ix) to promote the working of safety committees and to act as an advisor to such committees;

(x) to organise, in association with concerned departments, campaigns, competitions, contents and other activities which will develop and maintain the interest of building workers in establishing and maintaining safe conditions of work and procedures;

(xi) to design and conduct, either independently or in collaboration with other agencies, suitable training and educational programmes for prevention of accidents to building workers;

(xii) to frame safe rules and safe working practices in consultation with senior officials of the establishment;

(xiii) supervise and guide safety precautions to be taken in building and other construction work of the establishment.

Fatal accident shall be reported - within 4 hours and non-fatal - causing disability of more than 48 hours - accident shall be reported within 72 hours to the Regional Labour Commissioner (Central), Board, Director General and the near relative of the deceased. It should be in the Form No. XIV.

Procedure for enquiry into cases of accident or dangerous occurrence is also prescribed u/r 211,

Chapter-XXII Explosives (R. 212, 213) :

All explosives at construction site should be used, stored or handled as per MSDS and provisions of the Explosives Act and Rules. Prohibition of smoking and sources of ignition, safe distance and use of nonsparking tools while opening packing, prior warning and danger signals before use, avoiding injury and use under supervision are all necessary.

Chapter-XXIII Piling (R. 214 to 222):

Provisions are made for good design, construction, operation, inspection and maintenance of pile driving equipment, considering ergonomic principles, electrical safety, air or steam hammer, stability of adjacent structure, protection of operator, instruction and supervision, entry of unauthorised person, working platform on piling frames and pile testing.

Chapter-XXIV Medical Facilities (R. 223 to 232):

Provisions are made for pre and periodical medical examination of workers as per Sch-VII, by the doctors and hospitals approved by the Central Government, certificate of medical examination in Form No. XI, record in Form No. XII, duties of construction medical officers, occupational health centre for hazardous processes mentioned in Sch. IX with services and facilities laid down in Sch. X and qualification of a Construction Medical Officer in Sch. XI, ambulance room equipped with the articles specified in Sch. IV with necessary staff and records, ambulance van specified in Sch. V, stretchers, occupational health services, notice of poisoning or occupational diseases specified in Sch. II and notice in Form No. XIII, first-aid boxes with articles specified in Sch. Ill and emergency care services or treatment with essential life saving aids and appliances as mentioned in R. 232.

Chapter-XXV Information to Bureau of Indian Standards (R. 233):

Details regarding performance, deviation or shortcomings of the building materials, articles or processes against IS prescribed shall be furnished to the Bureau of Indian Standards. In case of no IS prescribed, suggestions for improvement shall be given to the Bureau to consider and form necessary standards.

Chapter-XXVI Hours of work. Rest intervals and Weekly off etc. (R. 234 to 237) :

Provisions are made for 9 hours a day or 48 hours a week, rest interval of at least half an hour before more than 5 hours work, spread-over 12 hours on any day, double wages for overtime work or working on rest day, weekly rest day with its previous intimation notice, substituted holiday on one of the five days immediately before or after such rest day and to be given before ten days continuous working.

Chapter-XXVII Notices, Registers, Records and Collection of Statistics (R. 238 to 242) :

Notices of rates of wages, hours of work, wage period, date of payment of wages, names and addresses of the concerned Inspectors and date of payment of unpaid wages in English, Hindi and local language with a copy to the concerned Inspector are required.

Notice of commencement and completion of work in Form No. IV before 30 days and notice of change in this notice within 2 days of the change are also necessary.

Following registers are required :

Register	Form No.
Register of workers	XV
Muster roll	XVI
Register of wages	XVII
Wage –cum-muster roll where a wage period is 15 days or less	XVIII
Register of deductions for damage or loss	XIX
Register of fines	XX
Register of advances	XXI
Register of overtime	XXII
Wage book (for a wage period one week or more)	XXIII
Service certificate	XXIV

Registers under Payment of Wages Act, Maternity Benefit Act and Contract Labour Act shall be deemed to be the respective registers. A combined or alternative form in lieu of above Forms shall require -prior approval of the Central Government. All registers/records should be maintained up-to-date, kept at the workplace, preserved for 3 years and produced on demand before the authority.

An annual return in Form No. XXV shall be sent before 15th February to the registering authority with a copy to the Inspector concerned.

Chapter-XXVIII Welfare (R. 243 to 247) :

Separate latrines or urinals (as required u/s 33 of the Act) for male and female workers, canteen for more than 250 workers at a distance 15.2 mt away from any latrine, urinal or source of dust, smoke or obnoxious fumes. Tea and snacks shall be served at a workplace 200 mt from the canteen.

Chapter-XXIX Wages (R. 248, 249) :

Wages shall be paid before 7th day (workers<1000) or 10th day (workers>1000) of the wage period concerned. In case of termination it shall be paid before the expiry of the second working day from the date of termination. A notice of wage period, date, time and place of payment shall be displayed in English, Hindi and the local language.

Chapter-XXX Powers of Director General and Inspectors (R. 250 to 252) :

Powers to engage experts and agencies and powers of Inspectors including prohibition order are prescribed.

The Building and other Construction Workers' Welfare Cess Act 1996 and Rules 1998 provide for levy and collection of cess on the cost of construction to generate fund for Building and other Construction Workers Welfare Board constituted under the main Act (Part 7.1).

7.3 Gujarat Building and Other Construction Workers (Regulation of Employment and Condition of Service) Rules, 2003

U/s 62 and 40 of the Act (stated in Part 7.1) the Government of Gujarat published these rules by notification dt. 18-8-2003. They came in to force from this date.

They are similar to the Central Rules stated in part 7.2 above.

Chapter 3 provides for constitution and working of State Advisory Committee. Rule 27 prescribes fees for 'Certificate of Registration' based on proposed number of workers. Chapter 7 provides for State Welfare Board for construction workers. Sch. 8 prescribes number of Safety Officers their qualification, duties etc. Sch. 12 prescribes TLV and STEL values for certain chemicals.

8. LAWS ON DOCK SAFETY :

8.1 Dock Workers (Safety, Health & Welfare) Act, 1986 :

This Act (No. 54 of 1986) was enacted on 712-1986. It came into force from 15-4-1987. It extends to the whole of India. It has 25 sections. It provides for the Safety, Health and Welfare of dock workers and for matters connected therewith. Definitions (S.2):

Appropriate Government means, in relation to any major port, the Central Govt., and, in relation to any other port, the State Govt.

Cargo includes anything carried or to be carried in a ship or other vessel.

Dock Work means any work in or within the vicinity of any port in connection with loading, unloading, movement or storage of cargoes and includes preparation of ship or. other vessel and cleaning, painting, chipping of any hold, tank, structure or lifting machinery or any other storage area in board, ship or dock.

Dock Worker means a person employed or to be employed directly or through any agency, on dock work.

Inspectors and the Chief Inspector of Dock Safety (S. 3 to 8) :

The appropriate Govt. can appoint them. They can enter any ship, dock, warehouse to check any dock work, make examination of the ship, dock, lifting machinery, cargo, gear, staging, transport equipment, premises etc, require documents, take evidence, copies, photograph, sketch, sample etc., hold inquiry into any accident, issue show cause notice relating to safety, health and welfare provisions, prosecute or prohibit any dock work in dangerous condition until measures have been taken to remove that danger. Inspector will not disclose information or complaint received by them. Appeal to the Chief Inspector should be made within 15 days.

Other Provisions:

The appropriate Govt. may constitute an Advisory Committee for advice regarding administration of this Act and the regulations (S. 9). It can also appoint a competent person to inquire into any accident or occupational disease to dock workers (S. 10). Dock workers will not misuse anything provided to secure health, safety and welfare of dock workers, will not do anything to endanger self or others and, will not neglect to make use of anything provided as mentioned earlier.

Subjects of Regulations (S. 21) :

Regulations may provide for safety of working place, approaches, lighting, ventilation, temperature, fire & explosion prevention and protection, safe means of access, opening and closing of hatches and protection of dangerous openings, safety from fall, lifting and cargo handling appliances, workers employed in terminals, fencing of machinery, live electrical conductors, steam pipes, hazardous openings, staging, rigging and derricks, testing of lifting m/c, ropes, slings etc., escape routes, safe methods of working and handling dangerous substances or working in harmful environment, employing persons for handling cargo or any work on ship, transport of dock workers, precautions against noise, vibration and air pollution at workplace, protective equipment and clothing, sanitary, washing and welfare facilities, medical supervision, ambulance room, first-aid and rescue facilities, safety and health organisation,' training of dock workers, investigation of accidents, dangerous occurrences and diseases, forms of notices, authorities to be reported, submission of statement of accidents, man-days lost, volume of cargo handled and particulars of dock workers.

8.2 Other Acts, Rules & Regulations for Dock Workers :

(1) Dock Workers (Safety, Health and Welfare) Regulations, 1990:

They came into force from 16-3-1990. They apply to major ports in India as defined in the Major Ports Act, 1963. They have 7 parts, 112 regulations, 14 forms and 4 schedules.

Regulation 2 has 27 definitions including container, container terminal, conveyor, dangerous goods, dock, hatch, lifting appliance, loose gear, pulley block, responsible person, safe working load, transport equipment etc.

Reg. 3 is regarding power of inspectors. •

Part 3 (Reg. 9-94) is on safety containing subjects of fencing, railings, staging, life saving appliances, illumination, fire protection, excessive noise, means of access, ladders, lifting appliances and gear, test and examinations, winches, ropes, heat treatment of loose gears, marking of SWL, pulley blocks, power trucks, hand trucks, fork lifts, dock railways, conveyors, handling of cargo, stacking and unstacking, cargo platforms, winch and crane operations, signaller, handling of dangerous goods, general precautions, explosive and inflammable cargo, broken or leaking containers, toxic solvents, fencing of terminals, stuffing and destuffing, fencing of motors, transport of dock workers by land .and water, reporting of accidents, notification of diseases, safety officers and renewal of licences.

Part 4 (Reg. 95-99) is on Health containing provisions of cleanliness, drinking water, latrines and urinals, spittoons and ventilation and temperature.

Part 5 (Reg. 100-109) is on Welfare containing provisions of washing facilities, first aid boxes, ambulance rooms, shelters, canteens, medical examinations/notices and welfare officers.

Part 6 (Reg. 110-118) is on Special provisions like statement of accidents, training, emergency action plans, safety committees, occupational health services and general safety.

(2) Dock Workers (Safety Health and Welfare) Scheme, 1961:

Under section 4 of the Dock Workers (Regulation of Employment) Act, 1948 this Scheme is formed. It came into force on 1-10-1961. It has 5 parts, 60 paras, 4 schedules and 2 forms.

Para 2 gives 8 definitions including competent persons, dock, port authority etc.

The scheme contains the provisions of - powers of inspectors, notice of accidents and dangerous occurrences, diseases, duties of port authorities, obligations of dock workers and provisions regarding health and welfare of dock workers.

Part 4 on Safety (para 22 to 57) contains provisions of fencing of dangerous places, gates, floor loading, stairs, means o escape in case of fire, testing, annealing, special gear, ropes, drivers of cranes, cargo platforms, conveyors, power trucks, and hand trucks, locomotives and wagons, stacking and un stacking, precautions against falling material, corrosive and caustic substances, dust fume, etc., oxygen deficiency, fumigated spaces, machinery, ladders, fire protection and rescue.

9. LAWS ON LIFTS AND ESCALATORS

9.1 Gujarat Lifts and Escalators Act 2000

Preamble of this Act states that its object is to regulate construction, maintenance and safe operation of lifts and escalators and the machinery and apparatus pertaining thereto in the State of Gujarat.

It came into force from 15-6-2001 and extends to whole of the State of Gujarat. It has 26 sections.

As clarified in the Statement of Objects and Reasons, this Act replaces the Bombay Lifts Act 1939

Sec 2 gives 14 definitions.

'Lift' means an appliance designed to transport persons or materials between two or more levels in a vertical or substantially vertical direction by means of a guided car or platform;

'Lift car' means the load carrying unit with its floor or platform car frame and enclosing body work;

'Lift installation' includes the lift car, the lift way, the lift way enclosure and the operating mechanism or the lift and all ropes, cables, wires and plant, directly connected with the operation of the lift;

'Escalator' means a power driven inclined continuous stairway used for raising or lowering passengers;

'Escalator installation' includes the escalator, the track, the trusses or girders, the balustrade, the step treads and landings and all chains, wires and plants directly connected with the operation of the escalator;

'Rated speed' means the speed at which the lift or escalator is designed to operate;

Permission before installation (erection) is necessary (S.3).

After completion of installation, owner should apply within one month to get licence to operate the lift or escalator. Validity of licence is 3 years. Before 30 days of expiry, renewal application is necessary (S.6). No operation without licence. Conditions are to be fulfilled (S.7). Addition/alteration requires prior permission (S.9). For violation of the Act, Rules or Conditions; licence can be suspended or cancelled.

Owner has to give facilities for inspection (S.12). The Chief Inspector may authorise a person for erection, maintenance, inspection and test. (S13).

Accident (death or injury) is to be reported to the Lift Inspector, Police Commissioner and District Magistrate. (S14) . -

Inspectors under the Electricity Act will be the inspectors under this Act.

Every lift or escalator shall be inspected by lift inspector before grant of licence u/s 4 and thereafter at every 3 years. The owner of the lift or escalator shall get his lift or escalator inspected and tested by an authorised person (u/s 13) at every six months and submits such inspection and test report to the Chief Inspector. The authorised person shall also submit his report to the Chief Inspector. (S 16).

9.2 Gujarat Lifts and Escalators Rules 2001

U/s 24 of the Act, these rules were notified. They came into force on 16-6-2001. It has 73 rules and 21 Annexure. Forms are contained in annexure.

In Rule 2, there are 81 definitions most of which are technical terms. Some are given below

(1) "Automafic control" means a method of operation by which a momentary pressure on a push button sets the car in motion and causes it to stop automatically at any required lift landing;
(2) "Buffer" means a device designed to stop a descending car or counter weight beyond its normal limit of travel by storing or by absorbing and dissipating the kinetic energy of the car or counterweight;
(3) "Car frame" means the supporting frame or sling to which the platform of the lift car, its safety gear, guide shoes and suspension ropes are attached;
(4) "Control" means the system governing starting, stopping direction of motion, acceleration, speed and retardation of moving member;

(5) "Counter weight" means a weight or series of weights to counter-balance the weight of the lift car and part of the rated load;
(6) "Door-imperforated" means a door which is not having any perforations other than those required for vision panel for maximum size 100 Square centimetre;
(7) "Emergency stop push or switch" means a push button or switch provided inside the car designated to open the control circuit to cause the lift car to stop during emergency;
(8) "Gear less machine" means a lift machine in which the motive power is transmitted to the driving sheave from the motor without intermediate reduction gearing and has the brake drum mounted directly on the motor shaft;
(9) "Geared machine" means a machine in which the power is transmitted to the sheave through worm, or worm and spur reduction gearing;
(10) "Lift machine" means the part of the lift equipment comprising the motor(s) and the control gear therewith, reduction gear (if any), brake(s) and winding drum or sheave, by which the lift car is raised or lowered;
(11) "Over speed governor" means a device which brings the lift car and/or counterweight to rest by operating the safety gear in the event of the speed in a descending direction exceeding a predetermined limit;
(12) "Safety gear" means a mechanical device attached to the lift car or counterweight or both, designed to stop and to hold the car or counterweight to the guides in the event of free fall, or, if governor operated, of over-speed in the descending direction;
(13) "Sheave" means a rope wheel, the rim of which is grooved to receive the suspension ropes but to which the ropes are not rigidly attached and by means of which power is transmitted from the lift machine to the suspension ropes;
(14) "Slack rope switch" means switch provided to open the control circuit in case of slacking of rope(s);
(15) "Trailing cable" means a flexible cable providing electrical connection between the lift car and a fixed point or points.

Chapter-2 on 'General requirements' requires-

Prior permission to install lift or escalator with drawings (R3), licence to use (R4), renew at 3 years (R8), compliance of safety provisions ie chapter-3 & 4 (R7), terms & conditions to be fulfilled by the owner (R9), appointment of lift attendant (except residential premise) (R-12), intimation of accident in Annex-XVI within 48 hours (R-13) conformity with Indian Standards (R-17), conformity with National Building Code (R-18) conformity with Electricity Act and Rules (R-20), factor of safety 5 and more, periodical inspection and testing (R-23), quiet operation(R24) and separate electric circuit for lift or escalator.(R25)

Chapter-3 on lifts

Prescribes detailed engineering provisions of lift wells (R 26), lift well enclosure (R 27), lift pite '(R28), bottom & top car clearances &: gravity stopping distance (S=5/V2 v is initial velocity)(R-29), counterweight clearance (R 31), landing doors imperforate, their strength, fire resistance of more than one hour (R 32), door interlocking (R-33), guide rails (R 34), buffers of spring or oil, (R 35), counter weights (R36), lift car-its enclosure, door, floor, emergency stop device, light, alarm, stop switch, fire lift (R37), load/ capacity plate, car area depending on load (R38), car frame (R39), safety gears with speed governor to stop descending car, such device on counter weight to stop ascending car, slack rope safety gear, stopping distances at governor tripping speed (R40), machine room (R42), outline dimensions (R43), sheaves &: pulleys (R44), lift machine (R 45), suspension by three ropes, no use of chain, rope dia > 10 mm, factor of safety 10 to 12 (R 46), controllers & operating devices (R47), terminal stopping and final limit switches (R48), electric wiring & switches (R49), testing at site (R50) and other precautions like no operation by unauthorised person etc (R51).

Chapter -4 on Escalators

Prescribes angle of inclination -30 to 35 degree from horizontal with vertical rise not more than 6 mts (R52), width of escalators, not more than 33 cms of step width (R53), balustrading (R 54), hand rail moving with the step, height > 30 cms (R55), step dimensions depth > 40 cms, rise < 22 cms and width 40 to 102 cms (R56), comb plates (R57), trusses or girders (R58), track arrangement of step wheel, running gear and step chain brakes (R59), capacity & loading (R60), rated speed < 38 mt/min (R61), independent motor drive & brake (R62), chain with factor of safety >.10 (R63), safety devices including start switch, stop switch and speed governor (R64), machine room (R65), lighting of step tread > 20 lux (R66), access to interior of escalator (R67), tests for rated load, over speed, reversal, broken chain and stop buttons (R68) and other precautions like attendant, no inadvertent starting, fire extinguisher, cleaning, lubrication etc. (R69)

Annex XIII requires appointment of at least one mechanical engineer (BE with 4 years & DME with 8 years experience) and one electrical engineer (BE with 4 years & DEE with 8 years experience), workshop with prescribed instruments to get certificate of authorization u/r II. See Annex - XIV also.

Different authorizations for erection &: maintenance of lifts or escalators and their periodical inspection and testing are available.

Annex-XVIII u/r 23 for initial and periodical inspection report of lift and Annex-XIX of escalator are most important.

10. LAWS ON ENVIRONMENTAL PROTECTION:

10.1 Water (Prevention and Control of Pollution) Act 1974 :

This Act (No. 6 of 1974) was enacted by the Parliament on 23-3-1974. It is applicable to the States from their dates of their adoption. It was amended in 1978 and 1988. '

It has 8 chapters and 64 sections. It applies to certain States and the States who adopt it.

The Act intends to provide for the prevention and control of water pollution, maintaining or restoring of wholesomeness of water. Boards, its powers and functions for matters connected therewith.

Chapter-1 gives following definitions :

Board means the Central or a State Board.

Outlet includes any conduit pipe or channel, open or closed, carrying sewage or trade effluent or any other holding arrangement which causes or is likely to cause pollution.

Pollution means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (directly or indirectly) as may or is likely to create a nuisance or render such water harmful or injurious to public health or safety or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms.

Central Board, State Board, Sewage effluent and Trade effluent are also defined and distinguished.

Stream includes river, water course, inland water, sub-terranean waters and sea or tidal waters to the extent notified.

Sewer means any conduit pipe or channel, open or closed, carrying sewage or trade effluent.
Subjects of other chapters are as under :

Chapter I	:	Preliminary (S. 1,2)
Chapter II	:	Central & State Boards (S.3 to 12) Chapter ID : Joint Board (S. 13 to 15).
Chapter IV	:	Powers & Functions of Boards (S. 16 to 18).
Chapter V	:	Prevention and Control of water Pollution (S. 19 to 33A)
Chapter VI	:	Funds, Accounts & Audit (S. 34 to 40) Chapter VII : Penalties & Procedure (S. 41 to 50)
Chapter VIII	:	Miscellaneous including rule making powers of the Central and State Govts. (S. 51 to 64).

Functions of the State Board given u/s 17 are more important.

Some provision of Chapter-V are explained below -

A State Board can require from any industry, operation, process, treatment and disposal system to furnish information regarding construction, installation or operation of such establishment (S.20), can take samples of effluents in a manner prescribed for analysis at the occupier's cost (S.21), shall send a copy of the report of analysis to the occupier (S.22), has power of entry and inspection of plant, record, register, document, material etc. (S. 23) and of prohibiting use of stream or well or sewer or on land for disposal of polluting matter by prescribing standards and no person shall make water pollution (R. 24) or make any new outlets or new discharges without previous consent of the State Board, which will make inquiry and grant consent with conditions imposed (which shall be binding to the applicant) or refuse it with reasons recorded in writing. If the consent is not given or refused within 4 months, it should be deemed to have been granted unconditionally (R. 25 & 26).

An aggrieved person has right to appeal u/s 28. Revision is possible u/s 29.

Any accident, act or event causing water pollution should be forthwith intimated to the State Board (S. 31). The State Board can take steps to remove pollution or such discharges (S. 32) or apply to courts for restraining apprehended water pollution and the court can order the person to remove that pollution or authorise the Board to do it at the cost of that person (S. 33). The State Board has power to give directions to any person, officer or authority for closure, prohibition or regulation of any industry, operation or process or the stoppage or regulation of supply of electricity, water or any other service (S. 33A).

Annual report (financial year wise) to be submitted by SPCV to state Govt. and by CPCB to Central Govt. (S. 39)

10.2 Water (Prevention and Control of Pollution) Rules 1975 :

The Central Government u/s 63 of the Water Act made these rules effective form 27-2-1975. The) were amended in 1976, 1978, 1986, 1987 and 1989.

They have II chapters, 35 rules, 4 schedules and 15 forms under schedule 1. Their subject matter is a; under.

Chap-1 : Preliminary (R. 1,2)
Chap-2 : Service conditions of Members (R. 3 to 6)
Chap-3 : Power & Duties of the Chairman and Member Secretary and appointments o officer and employees (R. 7 to 9)

Chap-4 : Temporary association of persons witt Central Board (R. 10)
Chap-5: Consulting Engineer (R. 11 to 16).
Chap-6: Budget of the Central Board (R. 17 to 23)
Chap-7: Annual Report of the Central Board (R. 24)
Chap-8: Account of the Central Board (R. 25)
Chap-9: Analyst of the Central Board (R. 26, 26A)
Chap-10 : Central water laboratory (R. 27, 28)
Chap-11 : Powers & functions of the Central Board in relation to Union territories (R. 29 to 35).

In addition to above mentioned Central Rules, State Rules are also available as under.

Gujarat Water (Prevention and Control of Pollution) Rules, 1976 :

They were notified and came into force from 268-1976. They have 25 Rules and Forms A to H-V.

State water laboratory means that established u/ s 52 of the Act. Other provisions are pertaining to fees and allowances to members, quorum, order of business, minutes, appointment of consulting engineers, powers and duties of the chairman and those of member secretary, application for consent and its investigation, budget, annual report and statement of accounts etc.

10.3 Air (Prevention and Control of Pollution) Act, 1981:

This Act (No.l4 of 1981) was enacted on 293-1981. It came into force from 16-5-1981. It extends to the whole of India. It has 7 chapters and 54 sections.

It was amended ml987.

Chapter-1 gives following definitions (S I and 2):

Air pollutant means any solid, liquid or gaseous substance including noise present in the atmosphere in such concentration as to be injurious to human beings, other living creatures, plants, property or environment.

Air pollution means the presence of any air pollutant in the atmosphere.

Approved appliances means any equipment or gadget used for bringing of any combustible material or for generating or consuming any fume, gas or particulate matter and approved by the State Board for the purpose of this Act.

Chimney includes any structure with an opening or outlet from or through which any air pollutant may be emitted.

Control equipment means any apparatus, device, equipment or system to control the quality and manner of emission of any air pollutant and includes any device used for securing the efficient operation of any industrial plant.

Emission means any solid, liquid or gaseous substance coming out of any chimney, duct or flue or any other outlet.

Industrial plant means any plant used for any industrial or trade purposes and emitting any air pollutant into the atmosphere.

The words 'approved fuel' and 'automobile' arc also defined. Other chapters are as under :

Chapter - II :	Central & State Board (S.3 to 15)
Chapter - III :	Powers & functions of Boards (S.16 to 18)
Chapter – IV : :	Prevention & Control of Air pollution (S.19 to 31A)
Chapter – V :	Funds, Accounts & Audit (S.32 to 36).
Chapter – VI :	Penalties & procedure (S 37 to 46)
Chapter - VII:	Miscellaneous including rule making powers of the Central and State Govt. (S. 47 to 54).

Functions of the central and State Pollution Control, Boards are given in Chapter III.

Some provisions of Chapter-IV are as under :

The State Government may after consultation with the State Pollution Control Board, notify any area as air pollution control area for the purposes of this Act, prohibit the use of any polluting fuel in any area, require use of an approved appliance, prohibit burning of any polluting material in any area (S.19) and instruct the motor vehicles authority to ensure compliance of the standards of automobiles emission laid down by the State Board (S.20).

No industrial plant shall be established or operated without the previous consent of the State Board. An application for consent should be in a prescribed form. The State Board can grant or refuse within 4 months, or cancel any existing consent or refuse further consent after expiry if the conditions are not fulfilled. Every person getting consent has to comply with the following conditions.

1 The control equipment approved by the State Board, should be installed and operated.
2 The existing control equipment shall be altered or replaced as per the directions of the State Board.

3 The control equipment should be maintained at all times in good running condition.
4 Chimney, approved by the State Board shall be erected or re-erected.
5 Such other conditions as the State Board may specify
6 The conditions should be fulfilled within a stipulated time.

Due to any technological improvement or otherwise the State Board can vary its conditions. If the consent is transferred to another person, the transferee will be responsible for compliance (S. 21).

Standards laid down by the State Board shall not be exceeded (S.22). The Board has power to approach the court for restraining persons from causing air pollution. The court can direct that person to stop pollution or authorise the Board to implement the direction at the cost of that person (S.22A).

An accident, unforeseen act or event of emission beyond the prescribed standard shall be forthwith intimated to the State Board and to the prescribed authorities, who shall take, as early as practicable, remedial measures to mitigate that emission at the cost of the person concerned (S.23).

Board officers have power of entry and inspection to check conditions, control equipment, industrial plant, record, register, document, material etc. (S.24) and can call for any information regarding types and level of emission and any compliance necessary (S.25), can take samples of air or emission in the manner prescribed and can send the sample to the laboratory for analysis (S.26). The Board analyst shall submit the report of analysis in triplicate to the Board, of which one copy will be sent to the occupier by the Board (S.27).

The State Government can establish one or more State Air Laboratories (S.28) and can appoint analysts (Govt. analysts). The Board can also appoint analysts (Board analysts) (S.29) whose report can be used as a evidence in any proceeding under this Act (S.30).

An aggrieved person can appeal within 30 days to the prescribed authority (S.31).

Central or State Board has power to give directions to any person, officer or authority who shall comply with such directions. Such power includes the power to direct closure, prohibition or regulation of any industry, operation or process or the stoppage or regulation of supply of electricity, water or any other service (S. 31A).

10.4 Air (Prevention and Control of Pollution) Rules, 1982 :

The Central Government u/s 53 of the Air Act made these rules effective from 18-11-1982. They have 7 chapters, 17 rules, 3 schedules and 9 forms. The subject matter is as under :

Chapter - I	Preliminary (R.l,2)
Chapter - II	Procedure for the Board and its committees (R.3 to II).
Chapter - III	Allowances to a committee member to attend the meeting (R.12).
Chapter - IV	Temporary association of persons with the Central Board (R.13, 14).
Chapter -V	Budget of the Central Board (R.15).
Chapter-VI	Annual Report of the Central Board (R.16).
Chapter - VII	Account of the Central Board (R.17).

In addition to above mentioned Central Rules, State Rules are also available as under.

Gujarat Air (Prevention and Control of Pollution) Rules, 1983.

They were notified and came into force from II11-1983. They have 25 Rules, 2 Schedules and Forms I to II.

Rule 2 gives 12 definitions.

Furnace means any structure or installation where any form or type of fuel is burnt or otherwise a high temperature higher than ambient is maintained.

State Laboratory means that established u/s 17 of the Act.

Other provisions include terms, conditions and functions of the State Board, appointment, fees and tours of consultant, air pollution control area, application for consent and its inquiry, manner of taking samples of air, functions of state air laboratory, qualifications for Govt. analyst and board analyst, appeals, budget, annual report and statement of accounts etc.

10.5 Environment (Protection) Act, 1986 :

This Act (29 of 1986) was enacted on 23-51986. It came into force, from 19-11-1986 in the whole of India. It has 4 chapters and 26 sections.

The Statement of Objects and Reasons of the Act identifies the need for a general legislation on environmental protection to enable co-ordination of activities of the various regulatory agencies, creation of an authority which will assume a lead role for studying, planning and implementing long-term requirements of environmental safety and give direction to and co-ordinate a system of speedy and adequate response to emergency situations threatening the environment.

Its preamble states that it is an Act to provide for the protection and improvement of environment and for matters connected therewith

Chapter -I : Preliminary (S.I, 2) :

Some definitions are as under :

Environment includes water-air and land and the inter-relationship which exists among and between , air and land and human beings, other living creatures, plants, micro-organism and property [S.2(a)].

Environmental pollutant means any solid, liquid or gaseous substance present in such concentration as to be injurious to environment, [S.2(b)].

Environmental pollution means the presence of any environmental pollutant in the environment, [S.2(c)]

Handling in relation to any substance, means the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, offering for sale, transfer or the like of such substance [S.2(d)].

Hazardous Substance means any substance or preparation which by reason of its chemical or physiochemical properties or handling is liable to cause harm to human beings, other living creatures, plant, microorganism, property or the environment., [S.2(e)].

Chapter - II : General Powers of the Central Government (S. 3 to 6):

The Central Govt. has power to take all necessary measures to protect and improve the quality of environment and to prevent, control and abate environmental pollution, co-ordinate action by the State Govts, officers and other authorities and has power of planning and execution of a nation wide programme, laying down standards for the quality of environment, standards for emission of pollutants, procedures and safeguards for the prevention of accidents which may cause environmental pollution and for the handling of hazardous substances, examination of processes, materials and substances and empowering officers for that, carrying out research and investigation, establishing environmental laboratories, collection and dissemination of information, preparation of manuals, codes or guides for prevention, control and abatement of environment pollution and constituting authorities to carry out these functions (S.3).

The Central Govt. can appoint officers for above purposes (S.4), can give directions to any person, officer or authority including direction of closure, prohibition or regulation of any industry, operation or process or stoppage or regulation of supply of electricity, water or any other service (S.5). It has power to make rules (S.6, 25, 26) and power to delegate its powers and functions (S.23).

Chapter-III : Prevention, Control and Abatement of Pollution (S. 7 to 17) :

Environmental pollutants in excess of .standard prescribed shall not be discharged (S. 7). While handling hazardous substance prescribed procedure and safeguards shall be followed (S. 8). Excess discharge shall be forthwith reported to the authorities and steps shall be taken to prevent or mitigate such accidental pollution. The authorities shall also take similar steps at the cost of the person concerned (S. 9).

Persons empowered by the Central Government have powers of entry and inspection, examination and testing of any equipment, industrial plant, record, register, document, material etc. (S. 10), to take samples of air, water, soil or other substance from any factory, premises or other place in a manner prescribed and to send them to the laboratory for analysis (S.ll), to establish environmental laboratories (S.12). Sec. 14 is regarding Central Analysts (S. 13) whose report can be produced as an evidence in proceeding under this Act, (S. 14).

Provisions are made for penalty (S. 15) and offences by companies (S. 16) and Government Departments (S. 17).

Chapter - IV : Miscellaneous (S. 18 to 26):

Provisions are made for protection of action in good faith (S.18). Cognisance of offences by the authority as well as any person who has given notice of at least 60 days of the alleged offence and his intention to complain, to the authority concerned (S.19). Information, reports or returns (S.20) and no civil court has any jurisdiction in respect of anything done by the authority or the Central Government (S.22). This Act has overriding effect notwithstanding anything inconsistent with any other Act but if any offence is punishable under this Act and also under any other Act, then the offender shall be punished under the other Act and not under this Act (S.24).

10.6 Environment (Protection) Rules, 1986 :

The Central Government u/s 6 & 25 of the Environment (protection) Act made these rules effective from 19-11-1986. They were amended in 1987, 1988, 1989, 1991,1992, 1993 and from 1996 to 2006 every year.

They have 14 rules, 7 schedules, (No.2 omitted) 4 Annexures under schedule IV, 5 Forms under AnnexureA and different Notifications dating from 212-1991 and onwards specifying guidelines, area categories, requiring environmental clearance from the listed projects (schedule) and forming the expert committees for environmental impact assessment. An abstract of provisions is as under:

Areas means all areas where the hazardous substances are handled.

Recipient system means the part of the environment such as soil, water, air or other which receives the pollutants.

Central Board means the Central Pollution Control Board u/s 3 of the Water Act and State Board means a State Pollution Control Board u/s 4 of the Water Act or u/s 5 of the Air Act,

Standards : The standards for emission or discharge of environmental pollutants are specified in schedule I to IV. The Central or State Board may specify more stringent standards. These standards shall be complied with by an industry, operation or process within a period of one year of being so specified. The board can reduce this period. Industries, operations or processes not mentioned in Sch. I shall not exceed the general standards specified in Sch. VI. No emission or discharge shall exceed the relevant concentration set out in column (3) to (5) of Sch. VH of National Ambient Air Quality Standards (NAAQS) (R. 3).

See Parts (Tables) 10 to 14 of Chapter-32.

Others : All directions u/s 5 should be in writing and specify action to be taken and its time of compliance. Procedure is prescribed (R.4). Factors to be considered while 'prohibiting or restricting the location of industries are given in R.5. Procedure for taking samples (R.6), Notice in Form I to take sample (R.7), Procedure for submission of samples alongwith From n and form of laboratory report in Form III (R'8), Functions of laboratories (R.9), Qualifications of Govt. Analyst (R.IO), Manner of giving notice of alleged offence in Form IV (R. II), Notice, of accidental discharge to the authorities (R.I 2) and Sch. V, Factors to be considered while prohibiting or restricting the handling of hazardous substances (R.13) and submission of Environmental Statement for the financial year ending 31st March in Form V before the next 30th September every year to the Board (R.14) are prescribed.

Schedule-1 (Rule-3) : gives industry wise pollution parameters and their standards for 98 types of industries including stack height and test method for some parameters and also known as Minimum National Standards (MINAS).

Schedule-II (Rules-3) : was inserted on 12-9-1996 and omitted on 31-12-1993. thus now it does not exist.

Schedule-III (Rule-3) : gives ambient air quality standards for noise for 4 categories of area and time. Limits in dB vary from 40 to 75.

Schedule-IV (Rule-3) : specifies standards for vehicular emission, types of fuel and tests and exhaust gas values in Annexures I to IV. Parameters considered are CO, HC and NO..

Schedule-V (Rule-12) : gives authorities to be informed in case of excessive discharge. This includes authorities under the Atomic Energy Act, Factories Act, Mines and Minerals Act, Ports Act, Plantations Labour Act, Motor Vehicles Act and Merchant Shipping Act.

Schedule-VI (Rule-3A) : gives general standards for discharge of pollutants in five parts : (A) Effluents (B) Waste water generation (C) Load based standards for Oil Refinery and large Pulp & Paper mill (D) General emission standards based -on concentration, equipment and load/mass (E) Noise standards for automobiles and domestic appliances and also gives guidelines in Annexure I fell for the purposes of Part A to D.

See Table-14 in Chapter-32.

Schedule-VII (Rule-SB) : gives National Ambient Air Quality Standards (NAAQS) in terms of time weighted average concentration in ambient air (ug or mg/nr") for six main pollutants – SO_2, NO_2, Pb, CO, SPM (Suspended particulate matter) and RPM (respirable particulate matter) with their method of measurement. This table may be useful in keeping work environment record (e.g. Form 37 GFR). See 2nd Sch. under the Factories Act for in-plant exposure limits.

See Table-15 in Chapter-32.

Appendix -A prescribes Form I (R.7), II & III (R.8), IV (R.11) and V, Annual Environmental Statement (R.14).

10.7 Hazardous Wastes (Management and Handling) Rules, 1989:

The Central Government u/s 6,8 & 25 of the Environment (Protection) Act made these rules effective from 28-7-1989.

They were amended in 1996, 2000, 2003 i

They have 21 rules, 8 schedules and 13 forms.

Application (R.2) : These rules apply to hazardous wastes as specified in Schedules, but do not apply to Waste water and exhaust gases, wastes arising out of operation from ships beyond 5 km, radio-active wastes, biomedical wastes, municipal solid waste; lead acid batteries wastes as there are separate rule for them.

Definitions (R.3):

There are 36 definitions some of which are a under:

Applicant means a person or organisation the applies in Form-1 for granting authorisation for handling of hazardous waste.

Authorisation means permission for collection transport, treatment, reception, storage and disposal of hazardous wastes granted by the competent authority in Form-2.

Hazardous waste means any waste which b reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances, and shall include wastes listed in Sch. 1, 2 & 3.

Disposal means deposit, treatment, recycling and recovery of any hazardous wastes;

Facility means a location wherein the processes incidental to the waste generation, collection, reception, treatment, storage and disposal are carried out.

Hazardous Wastes Site means a place duly approved by the competent authority for collection, reception, treatment, storage and disposal of hazardous wastes.

Operator of a facility means an owner or operator of the facility defined above.

The occupier generating hazardous wastes listed in the Schedules 1, 2 & 3 shall take all practical steps for safe disposal of the wastes either himself or through an operator of a facility. The occupier should supply specified (safety) information to the operator of a facility (R. 4).

Application for authorisation in Form-1 by the occupier or a facility operator and grant of such authorisation with conditions in Form-2 after satisfying that they possess appropriate facilities, technical capabilities and equipment to handle the wastes safely. Such authorisation lasts for validity specified by SPCB unless sooner suspended or cancelled and then needs renewal in Form-1. It can be refused also (R. 5).

If the conditions are not fulfilled, the granted authorisation can be cancelled or suspended by the State Pollution Control Board or Committee after a show cause notice and subsequent instruction for the safe storage of the hazardous wastes (R. 6).

Packing, labelling and transport of such wastes should, be in accordance with the Motor Vehicle Act and rules made there under and in a condition to withstand physical and climatic factors. Label as in Form 8 necessary (R. 7).

The occupier or operator of a facility shall identify wastes disposal site. EIA and public hearing are necessary (R.8).

Design and operation of the landfill site shall be as approved by SPCB (R. 8A & B).

The occupier generating waste and operator of a facility shall maintain records in Form-3 and shall send annual returns in Form-4. (R.9).

Any accident during transport or at the facility shall be reported immediately to the State Pollution Control Board or Committee in Form-5. (R.IO).

Import and export of hazardous wastes specified in Sch. 8 is not permitted for dumping and disposal. It may be permitted for processing or re-use as raw material and after getting necessary information in Form 6 & 6A from the exporter and importer both and after examining each case on Jnerit. The importer shall maintain records in Form-7A'"and allow inspection by the authority (R.II& 12).

Rule 13 to 15 are also for import and export. Rule 19 and 21 are for re-refining and recycling. R.20 states responsibility of wastes generator.

An appeal shall lie before the State or Central Government depending on order and as provided in R. 18.

Subjects of Schedules are as under :

Sch. No.	**Subject**

1	Process wise list of hazardous wastes
2	Concentration wise list of hazardous wastes
3	List of wastes for import and export
4 & 6	Recycling of wastes
5	Re-refining of wastes
7	Authorities
8	List of wastes prohibited for import and export.

10.8 Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 :

U/s 6, 8 and 25 of the Environment (Protection) Act. 1986, these rules were made enforceable from 27-11-1989. They were amended in 1994 & 2000.

They have 20 Rules and 12 Schedules asunder:

R1 - Short- title and commencement.
R2 - Definitions.
R3 - Duties of Authorities : To inspect the industrial activity at least once in a year and to perform duties mentioned in Sch. 5.
R4 - General responsibility of the occupier.
R5 - Notification of major accident.
R6 - Industrial activity to which rules 7 to 15 apply.
R7 - Approval & Notification of sites.
R8 - Updating of the site notification following changes in the threshold quantity.
R9 - Transitional provisions.
R10 - Safety Reports and Safety Audit Report.
R11 - Updating of reports u/r 10.
R12 - Requirement for further information to be sent to the authority.
R13 - Preparation of on site emergency plan by the occupier.
R14 - Preparation of off site emergency plan by the authority.
R15 - Information to be given to persons liable to be affected by a major accident.
R16 - Disclosure of information.
R17 - Collection, Development and Dissemination of information.
R18 - Import of hazardous chemicals.
R19 - Improvement notices.
R20 - Power of the Central Government to modify the schedules.

Then schedules as under -

Sch.1 - Indicative criteria and list of chemicals.
Part-I Toxic, flammable & Explosive chemicals.
Part-II List of 684 hazardous chemicals.
Sch.2 - Isolated storage other than those covered by Sch. 4. Threshold quantities of 30 chemicals are given.
Sch. 3 - List of hazardous chemicals for application of R. 5 and 7 to' 15. Part - I named chemicals, 179. Part - II classes of chemicals not named in Part - I (flammable gases and liquids)

Sch.4 - Hazardous operations and processes.
Sch.5 - Authorities and their duties (addition).
Sch.6 - Notification of a major accident.

Sch. 7 - Notification of sites.
Part-I regarding site,
Part-II regarding pipeline.
Sch. 8 - A safety report.
Sch. 9 - Safety data sheet (MSDS).
Sch. 10 - Record of hazardous chemicals imported.
Sch. 11 - Details of on - site emergency plan.
Sch. 12 - Details of off-site emergency plan.

Thus these rules impose greater duty on occupiers and authorities in identifying major accident hazard (MAH) installations and taking safety measures for them.

10.9 Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Micro-organisms, Genetically Engineered Organisms or Cells (1989) :

The Central Government u/s 6, 8 and 25 of the Environment Protection Act 1986, notified these rules on 5-12-1989 and brought in force from 1-10-1993 with a view to protect the environment, nature and health in connection with the application of gen-etechnology and micro-organisms.. It has 20 rules and a Schedule of Animal and Human pathogens. They apply to the whole of India.

Application (R.2):

These rules apply to :

1. Manufacture, import and storage of microorganisms and gene-technological products.
2. Genetically engineered organisms, microorganisms and cell and correspondingly to any substances and products and food stuffs etc. of which such cells, organisms or tissues hereof" form part.
3. New gene-technologies apart from those mentioned in Rule-3 and to organisms/microorganisms and cells generated by the utilisation of such other gene-technologies and to substances and products of which such organisms and cells form part.

The rules are applicable for sale, storage, handling, export, import production, processing, packaging, repackaging, drawing off such organisms and also to manufacture of drugs and pharmaceuticals, food-stuff, distilleries and tanneries etc. which make use of such organisms one way or the other.

Definitions (R. 3) :

Five scientific definitions are reproduced below:

1. "Biotechnology" means the application of scientific and engineering principles to the processing of materials by biological agents .to produce goods and services.
2. "Cell hybridisation" means, the formation of live cells with new combinations of genetic material through the fusion of two or more cells by means of methods which do not occur naturally.,
3. "Gene Technology" means the application of the gene technique called genetic engineering, include self cloning and deletion as well as cell hybridisation.
4. "Genetic engineering" means the technique by which heritable material which does not usually occur or will not occur naturally in the organisms or cell concerned, generated outside the organism or the cell and is inserted into said cell or organism. It shall also mean the formation of new combinations of genetic material by incorporation of a cell into a host cell, where they occur

naturally (self cloning) as well as modification of an organism or in a cell by deletion and removal of parts of the heritable material.

5. "Micro-organisms" shall include all the bacteria, viruses, fungi, mycoplasma, cells lines, algae, protodones and nematodes indicated in the schedule and those that have not been presently known to exist in the country or not have been rliurnvprpd in far

Competent Authorities (R. 4) :

Six committees are specified to recommend safety regulations, to bring out manuals of guidelines to ensure environmental safety, to lay down procedures for restriction or prohibition, to prepare uptodate onsite emergency plan, to approve or control the use of hazardous micro-organisms and experimental field trials, to inspect, investigate and take punitive action in case of violations, to review periodically the safety and control measures and to monitor safety regulations in installations at the district level as under

1. Recombinant DNA Advisory Committee (RDAC).

2. Review Committee on Genetic Manipulation (RCGM).

3. Institutional BioSafety Committee (IBSC).

4. Genetic Engineering Approval Committee (GEAC).

5. State Bio-technology Co-ordination Committee (SBCQ.

6. District Level Committee (DLC) in chairman ship of the District Collector. Other members are Factory Inspector, representative of Pollution Control Board, Chief Medical Officer or DHO as member (Convener), Agriculture Officer, representative of Public Health Engineering Dept. District Microbiologist /Pathologist (technical expert) and Municipal Commissioner.

Classification : Micro organisms are classified in two major heads as animal pathogens and plant pests and sub classified as bacterial, fungal, parasitic, viral, Rickettsial and Chlamydial agents and special category as listed in the Schedule (R. 5, 6).

Approval, Prohibition etc. : For any dealing or production, approval of the GEAC is necessary. Deliberate or unintentional release is not allowed. For food stuffs, additives and other products, approval is necessary. Before obtaining such approval an on-site emergency plan and site examination are necessary. Approval may be granted with conditions for 4 years, renewable for 2 years at a time. The GEAC will supervise the conditions (R. 7 to 14).

Report of Accident is required at District and State level. Effective steps will be taken to minimise or prevent the harmful effects to environment, nature or health (R. 16).

Off-site Emergency Plan is to be prepared by DLC with the help of occupiers handing hazardous micro-organisms (R.17).

Other provisions are also made for inspection and information regarding penalties (R.15), finance (R.18), appeal (R.19) and exemption from R. 7 to II (R.20).

The Schedule gives classification and names of animal and human pathogens and plant pests.

10.10 Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 :

The Central Govt. u/s 6, 8 and 25 of the Environment (Protection) Act, 1986 made these rules. They were notified and brought into force on 1-8-1996. They were amended in 1998.

They contain 13. rules and 8 schedules. Their abstract is as under : Definitions (R. 2):

They contain 12 definitions some of which are as under:

Chemical accident - See part 3.8 of Chap-2.

Industrial pocket means any industrial zone earmarked by the Industrial Development Corporation of the State Government or by the State Government.

Major Accident Hazards (MAH) Installation See part 3.55 of Chapter 2.

Off-site emergency plan means the plan prepared as per Sch. 12 u/r 14(1) of the MSIHC Rules. (similarly On-site emergency plan means that prepared as per Sch. II u/r 13(1) of the MSIHC Rules.).

'Major Chemical accident"

See Part 3.54 of Chapter 2.

Different Crisis Groups : The constitution of the Central, State, District and Local Crisis Group shall be as specified in Sch. 5,6,7 &: 8 respectively. The members of the Central, State and District Crisis Groups are empowered u/s 10(1) of the EP Act 1986 to enjoy those powers. The MAH installations shall aid, assist and facilitate the functioning of the District and Local Crisis Groups. Meeting of the Central, State, District and Local Crisis Group shall be held at 6 months, 3 months, 45 days and 30 days respectively. Functions of the Central, State, District and Local Crisis Groups given in Rule 5, 7, 9 and 10 respectively are summarised in the following Table.

Functions of the Crisis Groups (Rule 5, 7, 9 & 10):

Central Crisis Group (Rule 5)		**State Crisis Group (Rule 7)**	
1	Expert guidance	Same as functions No. 1 to 7 mentioned for group	
2	Monitoring of post accident situation and remedial measures to prevent recurrence.	8	Assistance of the State Govt. in planning, preparedness and mitigation of major accidents.
3	Post accident analysis and evaluation of responses.	9	Quarterly report to the CCG.
4	Review of District offsite emergency plans and reports received.		
5	Respond to queries		
6	Statewise list of experts.		
7	Financial and other help.		
8	Informatin to public.		
District Crisis Group (Rule 9)		**Local Crisis Group (Rule 10)**	
1	Expert guidance.	1	Preparation of local emergency

			plan for the industrial pocket and dovetailing of this plan with the Dist. Off-site emergency plan.
2	Preparation of Dist. Off-site emergency plan.	2	Training of persons and public
3	Review of all on-site emergency plans of MAH units.	3	Half-yearly mock drill and report to DCG.
4	Management of chemical accidents in the district.	4	Respond to public inquiries.
5	Monitoring of every chemical accident	5	Information to public.
6	Continuous information to the CCG and SCG.	6	Assistance to MAH units for informing persons likely to be affected.
7	Report of chemical accident within 15 days to SCG.		
8	Yearly mock drill and report to SCG.		

Information to the Public : The Central, State and Local Crisis Group shall provide information on request regarding chemical accident prevention, preparedness and mitigation to the public in their respective jurisdiction. The Local Crisis Group shall assist the MAH installations in taking appropriate steps to inform persons likely to be affected by a chemical accident (R. 13).

Crisis Alert system : The Central Govt. shall set up functional control room, information network with state and district control rooms, appoint staff and experts in control room, publish lists of (i) MAH installations (ii) Major chemical accidents in chronological order (iii) Members of the Central, State and District Groups and take measures to create awareness amongst the public to prevent chemical accidents (R. 4).

Schedules:

Sch. I to 4-the same as Sch. I to 4 of the MSIHC Rules 1989 or R 68J, GFR 1963.

Sch. 5 to 8- List of members for CCG, SCG, DCG and LCG respectively.

10.11 Bio-Medical Waste (Management & Handling) Rules, 1998 :

Wastes generated from hospitals, medical & health institutions, R & D organisation, laboratories and slaughter houses etc., where biological organisms are involved, have become an important source of environmental and public health problems. Generally these wastes are being disposed in the Municipal dumps.

The public have become aware of this problem and the issue was discussed in various forums. The major concern is proper disinfection, treatment and disposal of bio-medical wastes.

To evolve a proper system for regulation of treatment and disposal of medical wastes and in exercise of the powers conferred by Sections 6, 8 & 25 of the Environment (Protection) Act, 1986, the Ministry of Environment & Forests, Govt of India framed these rules and made effective from 27-7-1998. They were amended in 2000 -& 2003.

There are 14 Rules with 6 Schedules and 5 Forms. These Rules provide Duty of Occupier, Treatment & Disposal, Segregation, Packing, Transportation &: Storage, Prescribed Authority, Authorisation, Advisory Committee, Monitoring in Armed forces medical centres by CPCB, Annual Report, Maintenance of Records, Accident Reporting, Appeal and common disposal/ incineration sites.

Out of 19 definitions, some are as under :

"Animal House" means a place where animals are reared/kept for experiments or testing purposes;

"Authorisation" means permission granted by the prescribed authority for the generation, collection, reception, storage, transportation, treatment, disposal and/or any other form of handling of bio-medical waste in accordance with these rules and any guidelines issued by the Central Government.

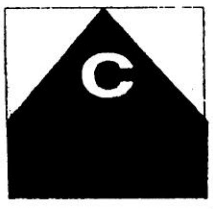
"Biologicals" means any preparation made from organisms or micro-organisms or product of metabolism and biochemical reactions intended for use in the diagnosis, immunisation or the treatment of human beings or animals or in research activities pertaining thereto;

"Bio-medical waste" means any waste which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals. There are ten categories of wastes and are listed in the Schedule-1. "Bio-medical waste treatment facility" means any facility wherein treatment, disposal of bio-medical waste or processes incidental to such treatment or disposal is carried out and includes common treatment facilities;

The Schedules are as under :

Sch. No.	Title
I	Categories of Bio-Medical waste.
II	Colour coding and type of container for disposal of Bio-Medical wastes.
III	Label for Bio-Medical waste containers / bags. (As shown below)
IV	Label for Transport of Bio-Medical waste containers / bags.
V.	Standards for Treatment & Disposal of Bio-Medical wastes like incineration, autoclave, liquid wastes, microwave system and deep burial;
VI	Schedule for Waste Treatment facilities like Incineration/ Auto Clave/ Microwave system.

Biohazard



Cytotoxic

The Forms are :

I	Application for Authorisation
II	Annual Report
III	Accident Reporting
IV	Authorisation
V	Application for Appeal

Schedule-I : Categories of Bio-Medical

Category No.	Waste Category	Treatment & Disposal
1	Human Anatomical Waste	incineration@/ deep burial*
2	Animal waste	incineration@/ deep burial*
3	Microbiology & Biotechnology waste	Local autoclaving / microwaving / incineration @
4	Waste Sharps	Disinfection (chemical treatment@ / autoclaving/ microwaving & mutilation / shredding*
5	Discarded medicines and Cytotoxic Drugs (wastes comprising of outdated, contaminated and discarded medicines)	incineration@/destruction and drug disposal in secured landfills
6	Solid Waste	incineration@/ autoclaving / microwaing
7	Solid waste	Disinfection by chemical treatment@ / autoclaving / microwaving and multilation / shredding##
8	Liquid Waste	Disinfection by chemical treatment@@ and discharge into drains
9	Incineration Ash	Disposal in municipal
10	Chemical Waste	Chemical treatment @ & discharge into drains for liquid and secured landfills for solids
@@	Chemicals treatment during at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be measured that chemical treatment ensures disinfection.	
##	Multination / shredding must be such so as to prevent unauthorized reuse.	
@	There will be no chemical pre-treatment before incineration. Chlorinated plastics shall not be incinerated.	
*	Deep burial shall be option available only in towns with population less than five lakhs and rural areas.	

Duty of Occupier:

It shall be the duty of every occupier of an institution generating bio-medical waste which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank by whatever name called to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment.

Treatment and Disposal:

1. Bio-medical waste shall be treated and disposed off in accordance with Schedule-1, and in compliance with the standards prescribed in Schedule-V.

2. Every occupier, where required, shall set up in accordance with the time schedule in Schedule VI, requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for - the treatment of waste, or ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. (R.5)

Segregation, Packaging, Transportation and Storage:

Biomedical waste shall not be mixed with other wastes. Segregation as per Sch.U and labelling as per Sch. III. For wastes being transported information as per Sch. III. Use of authored vehicle only. Untreated wastes not to be stored beyond 48 hrs. ,Role of municipality (R.6).

Maintenance of Records:

1. Every authorised person shall maintain record related to the generation, collection, reception, storage, transportation, treatment, disposal and /or any form of handling of biomedical waste in accordance with these rules and any guidelines issued.

2. All records shall be subject to inspection and verification by the prescribed authority at any time. (R.11)

Accident Reporting:

When any accident occurs at any institution or facility or any other site where bio-medical waste is handled or during transportation of such waste, the authorised person shall report the accident in Form-III to the prescribed authority forthwith. (R.12) SC Judgement:

In WP(Civil) No. 286/94 between BL Wadherav/ s Union of India, while monitoring its own judgement of 11-3-96, the Supreme Court went through 14 directions issued to various authorities and their compliance. Most of the Hospitals and Nursing homes in Delhi, agreed to provide incinerators or equally effective alternative for waste disposal.

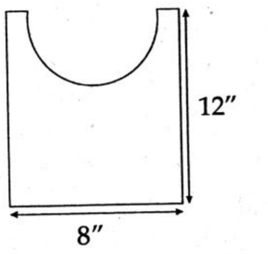
10.12 Plastics Manufacture, Sale and Usage Rules, 1999.

These rules came into force from 2-9-99 u/s 3 & 25 of the Environment (Protection) Act. 1986.

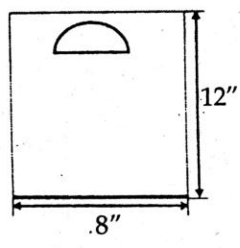
They were amended in 2003. They have 10 rules, I annexure and 2 forms.

Out of 7 definitions some are as under :

"Carry bags" means plastic bags which have a self carrying feature commonly known as vest type bags or any other feature used to carry commodities such as "T)" punched bags, as illustrated below.



Vest Type Beg



"D" Punched Bag

"Container" means flexible or rigid containers made of virgin plastics or re-cycled plastic with or without lid to store, carry or dispense commodities;

"Food-stuffs"" means ready to eat food articles and food products, fast food, processed or cooked food in liquid, powder, solid or semi-solid form;

Pollution Control Boards are prescribed authority for 'manufacture and recycling' processes and District Collector/Dy. Commissioner of the District for 'use, collection, segregation, transportation and disposal' provisions (R.3).

Rule 4 prohibits vendor to use carry bags or containers made of recycled plastics for storing, carrying, dispensing or packaging of foodstuffs. Rule does not permit to manufacture, stock, distribute or sale carry bags made of vergn or recycled plastic bag of size less than 8x12 inch (20 x 30 cm) and thickness less than 20 microns. Minimum weight of 50 carry bags shall be 105 gms ± 5% variation. (R. 4 & 8)

Rule 5 gives two conditions to manufacture plastic bags/containers :

1. Virgin plastic should be used in natural shade or white.
2. Recycled plastic used for purposes other than storing and packaging foodstuff may be used with pigments and colourants as per IS:9833.

Rule 6 allows recycling of plastics strictly as per IS:14534 entitled 'The Guidelines for recycling of plastics'.

Marking or codification also as per above IS:14534. Percentage of recycled material is also to be marked. Words 'Made of recycled material or virgin plastic' are to be printed on packets of bags (R.7).

10.13 Noise Pollution (Regulation and Control) Rules, 2000

U/s 3, 6 & 25 of the Environment (Protection) Act 1986 these rules were made. They came into force from 14-2-2000. They were amended in 2000 & 2006.

Its objective is to (1) regulate and control noise producing and generating sources and to (2) maintain ambient air quality standards in respect of noise as specified in the Schedule.

They have 8 rules and I schedule.

Rule 2 has 8 definitions including zone, court, educational institution, hospital etc.

Area within 100 mts around hospitals, educational institutions and courts may be declared as silence zone. Area categorization should be made as industrial, commercial, residential or silence zone as shown in the Schedule (R.3)

Noise levels shall not exceed levels specified in the Sch. as under (R.4)

Area Code	Category of Area/ Zone	Limits in dB (A) Leq*	
		Day Time	Night Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone	50	40
Leq* = It is energy mean of the noise level over a specified period. Day time 6 am to 10 pm Nigh time 10 pm to 6 am.			

See similar table 12.8 in Chapter-12.

Written permission is necessary to use loud speaker or public address system. They cannot be used between 10 pm and 6 am except in closed premises like auditoria, conference rooms, community halls, banquet halls etc. State Govt. has power to permit use between 10 pm to 12 midnight subject to terms and conditions (R.5)

Authority has power to prohibit vocal or musical sound also if it causes annoyance, disturbance, discomfort etc to any person or public (R.8)

10.14 Ozone Depleting Substances (Regulation and Control) Rules, 2000

U/s 6, 8 & 25 of the Environment {Protection) Act 1986, these rules were made. They came into force from 19-7-2000.

They were amended in 2001, 2003, 2004 & 2005.

They have 15 rules, 12 schedule and 14 forms. There are 17 definitions u/r 20.

Ozone depleting substance means those listed in Sch. I (divided in 8 groups) existing by itself or in mixture.

No person shall produce or cause to produce any ozone depleting substance after the date specified in Sch. V unless he is registered with the authority specified in that Schedule (R.3).

Export, import and its and prohibition as per Sch. VI (R. 4 & 5) -

Sale of ozone depleting substance shall stop after the date specified in Sch V unless it is registered with the authority specified in that Schedule (R.6) Other provisions include regulation on purchase (R.7), on use (R.8), on import, export and sale of products containing ozone depleting substances (R.IO), on reclamation and destruction (R.11),on manufacture, import and export of compressors (R. 12) and prohibition on new investments with ozone depleting substances (R.9).

Monitoring and reporting requirements are 'given . inR.14&Sch.X.

Nothing in these rules shall apply to matters in Sch. VIII. '

10.15 Batteries (Management and Handling) Rules, 2001

U/s 6, 8, & 25 of die Environment (protection) Act 1986, these rules were made and brought into force from 16-5-2001.
They have 14 rules, I schedule and 9 forms.

They apply to every manufacturer, importer, reconditioner, assembler, dealer, recycler, auctioneer, consumer and bulk consumer involved in manufacture, processing, sale, purchase and use of batteries or components thereof.

There are 19 definitions u/r 3 some of which are as under -

"Battery" means lead acid battery which is a source of electrical energy and contains lead metal;

"Consumer" means a person using lead acid batteries excluding bulk consumers;

"Re-conditioner" means a person involved in repairing of lead acid batteries for selling the same in the market;

"Recycler" means an occupier who processes used lead acid batteries or components thereof for' recovering lead;

Responsibilities of manufacturer, importer, assembler and re-conditioner are stated in R.4 and those of dealer in R. 7, of recycler in R.8, of consumer in R. 10 and of auctioneer in R. II.

Importers have to register themselves (R.5 & 6). Registration procedure for recyclers is given in R. 9.

Prescribed authority is State Pollution Control Board (R.12). Duties of CPCB are mentioned in R. 13 and those of MoEF in R. 14 for records and returns.

Used batteries are to be collected back by the manufacturer and dealer and appropriate discount shall be given to the consumer. Safe transportation, no damage during storage and transportation and collected batteries are to be sent only to the registered recyclers.

Recycler shall mark 'Recycled' on lead recovered by him and create public awareness regarding hazards of lead and obligations of consumers to return used batteries only to the registered dealers or at the designated collection centres.

EXERCISE

1. Explain, State, Mention or Discuss :

1. Safety of persons inside the boiler.
2. General safety provisions under the Indian Electricity Rules 1956.
3. Statutory provisions of Refining of petroleum.
4. General provisions OR provisions of manufacture of explosives.
5. Pressure vessel and its fittings under the SMPV Rules 1981.
6. General provisions of Gas Cylinder Rules 2004.
7. Packing and labeling of pesticides.
8. Provisions of Atomic Energy Act OR that of Radiation Protection Rules.
9. Class labels for hazardous goods.
10. General-requirements of 'lifts' under the Gujarat Lifts & Escalators Rules.
11. Different Crisis Groups under the Chemical Accident (EPPR) Rules.
12. Restrictions to use loud speaker or public address system.
13. Provisions of the Ozone Depleting Substances Rules 2000.

2. Define or Explain the following terms :

1. Boiler.
2. Petroleum & its Class.
3. Cryogenic liquid.
4. Flammable compressed gas.
5. Filling density.
6. Composite cylinder.
7. Radioactive substance.

8. Dock Work.
9. Lift installation.
10. Pollution of Water.
11. Air pollutant.
12. Environment.
13. Micro-organisms.
14. Carry Bags.
15. Battery.

3. Write Short Note. on :

1. Boiler attendant.
2. Repair and Maintenance of Petroleum pipe line.
3. Hydraulic testing of mobile pressure vessel OR Transport of compressed gas by vehicle
4. Object and provisions of the Insecticides A 1968.
5. Radiographic Safety Officer.
6. Emergency Information Panel.
7. Safety Officer under the Building & Other construction Workers Rules 1998.
8. Provisions of Escalators.
9. Powers of Governments under the Environment (P) Act 1986 OR subjects of schedule under that Act.
10. Subject of Schedules under the MSIHC Rule 1989.
11. Categories of Bio-Medical Waste. L

4. Explain the Difference between :

1. Feed pipe and steam pipe of a boiler.
2. Boiler and Small Industrial Boiler.
3. Container and Tank of Petroleum.
4. Hot work and Protected work under the Petroleum Rules 2002.

5. LPG & CNG.
6. Lift and Escalator.
7. Over speed governor and Safety gear of a lift
8. Hazardous waste and Biomedical waste.
9. Re-conditioner and Recycler under the Batteries Rules 2001.

4. Comment on following explaining whether it is true or not :

1. Zone-2 hazardous area is more dangerous than zone-0.
2. Weight of explosive includes the weight of packing box.
3. Insecticides cannot be stored with flammable material.
4. Lift can also move in horizontal direction.
5. 'Threshold quantity' safety criteria require storage of quantity more than that quantity.
6. Recycled plastic can be used for packaging of food stuffs.
7. Virgin plastic carry bag can be of any colour.
8. Used batteries are to be collected back by the

Reference & Recommended Reading ;

1. Statute books of Acts & Rules mentioned in this Chapter.

Note : The Content mentioned in this Chapter must be updated with the amended law for the purpose

CHAPTER – 29

Social Security Legislation

THEME

1 EVOLUTION AND GROWTH OF THE DOCTRINE OF SOCIAL SECURITY

With the growth of civilised societies a desire for 'Social protection~ was also grown. Security of individuals and their families was hampered because of accident, injury, disablement, disease, old age, maternity, unemployment etc. Loss of income due to any reason was (and is) considered a 'social risk' as it affects not only the wage -earner but also his / her family and dependants. Therefore during Middle Ages the search for social protection evolved within the societies.

Some help was provided by Raja (the King), public authorities, trade unions or local groups. See Part 5.1 of Chapter I for Indian origin and Kautilys's Arthshashtra. Some examples are available in Roman era and France. The French Revolution set forth the right to security, mutual assistance and relief. With the beginning of 19th century due to industrialisation in European societies, working conditions, life and multifarious risks, insecurity was increased. The trade unions in Great Britain started to give unemployment benefits.

At the end of 19th century. King Bismarck of Germany set up the first compulsory social security scheme for wage earners in industry. .The scheme included sickness insurance (1884) and disablement and old age insurance (1889). In the beginning of 20th century European countries supported the mutual benefit society by subsidies. Prior to 1919, several national legislations established non contributory pension schemes. This initial scope was limited to workers of low salary. Amounts of medical care and sickness insurance schemes were limited. Disablement pensions and old - age and survivors' benefits had just started.

The First World War awoke the need to combat social insecurity more sensitively then in the past. The establishment of ILO in 1919 supported the movement of protection of workers against the main social risk and a large number of national laws were passed i Europe, North America, Japan and Australia.

Some ILO Conventions on social security are as under :

1. Workmen's Compensation (Agriculture), Con 1921 (No. 12.)
2. Workmen's Compensation (Accidents), Con 1925 (No. 17.)
3. Workmen's Compensation (Occupational Diseases), Con. 1925 (No. 18.)

4. Sickness Insurance (Industry) Con. 1927 (No. 24.)
5. Sickness Insurance (Agriculture) Con. 192i (No. 25.)
6. Old Age Insurance (Ind.) Con. 1933 (No. 35.)
7. Invalidity Insurance (Ind.) Con. 1933 (No. 37.)
8. Survivors Insurance (Ind.) Con. 1933 (No. 39).
9. Workmen's compensation (Occupational Diseases Con. (Revised) 1934 (No. 42.)

Some earlier ILO Recommendations are as under:

1. Social Insurance (Agriculture) Rec. 1921 (No. 17)
2. Workmen's Compensation (Minimum Scale) Rec. No. 22 (Jurisdiction), Rec. No. 23 (Occupational Diseases), Rec. No. 24, all of 1925.
3. Sickness Insurance Rec. 1927 (No. 29).
4. Invalidity, Old-Age and Survivors' Insurance Rec. 1933 (No. 43)

The modern doctrine of social security evolved after the end of the Second World War. In 1935 the United States adopted a social security law. New Zealand adopted the law in 1938. Lord Beverage's report of 1942 in UK stressed radical reformation of social insurance and allied services. Atlantic Charter (1941) also extended the object in countries who signed it. The decisive step towards wider and universal protection was made in 1944 by ILO by accepting following two international. instruments:

1. Income Security Recom, 1944 (No. 67)
2. Medical Care Recom, 1944 (No. 69)

Following are some ILO conventions subsequently adopted:

1. Social Security (Minimum Standards) Con.1952 (No.l02)
2. Equity of Treatment (Social Security) Con. 1922 (No. 118)
3. Employment Injury Benefits Con. 1964 (No.l21)
4. Invalidity Old-Age and Survivors Benefits Con. 1967 (No. 128)
5. Medical Care and Sickness Benefits Con. 1969 (No. 130)
6. Maintenance of Social Security Rights Con. 1982 (No. 157)

Similarly following are some subsequent recommendations:

1. Unemployment Provision Rec. 1934 (No. 44)
2. Income Security Rec. 1944 (No. 67)
3. Medical care Rec. 1944 (No. 69)
4. Employment Injury Benefits «Rec. 1964 (No. 121)
5. Invalidity, Old-Age and Survivors' Benefit Rec. 1967 (No. 131)
6. Medical Care and Sickness Benefits Rec. 1969 (No. 134)
7. Older Workers Rec. 1980 (No. 162)
8. Maintenance of Social Security Rights Rec. 1983 (No. 167)

None of these is ratified by India till 1995.

Above convention No. 102 gave one definition of social security' that includes nine contingencies: medical care, sickness benefit, unemployment benefit, old - age benefit, employment injury benefit, family benefit, maternity benefit, invalidity benefit, and survivor's benefit.

2. SOCIAL SECURITY FOR UNORGANISED WORKERS

As published in Economic and Political Weekly dated 12-8-2006, the National Commission for Enterprises in the Unorganised Sector (NCEUS) submitted its first report on Social Security for unorganized workers to the Govt. of India on 16-5-2006.

Its objective is to provide minimum social security with legal backing to @ 30 crore unorganised workers with independent earnings.

Benefits in this proposal are as under-

Health	-	Hospitalisation upto Rs. 15000.
Insurance	-	Maternity upto Rs. 1000 per delivery.
	-	Disability allowance uptol5 days @ Rs. 50 per day.
	-	Accident death cover Rs. 25000
Life Insurance	-	Rs. 15000.
Old age	-	For Age > 60 yrs., pension
Security		Rs. 200 pm to those below poverty line. For others Provident Fund.

Contributions are as under-

Rs. 1 per 'day (Rs. 365 per year) by worker, employer and Government. Contribution of workers below poverty line to be paid by the Central Govt. Where Employers cannot be identified, their contribution to be paid by the Central and State Govt. in the ratio of 3:1.

Financing is proposed through cess or social security tax. Except the old-age security, other benefits are based on insurance model. Workers above poverty line guaranteed 10% annual return of their Provident Fund. Contributions are to be collected through post offices. This scheme has not to disturb the existing other social security schemes. All unorganised earning workers are eligible irrespective of their occupation or duration of employment. It provides a national floor level social security to all informal workers throughout the country. National as well as State level social security boards have to play proactive role for the success of the scheme.

The scheme is proposed as "Unorganised Sector Workers' Social Security Bill, 2005".

The full. text of report is available on the website http://nceuis.nic.in/.

3 SOCIAL ACCOUNTABILITY

The concept of social accountability comes from two Sources

1. ILO and
2. Article 38, 39, 41, 43 and 47 of the Constitution of India.

As mentioned in Part-1 of this chapter, the doctrine of social security has long history considering social protection, social risk, right to security and general well being or welfare of the society. ILO Conventions and Recommendations provide international guidelines for social accountability.

As directive principle of state policy. Article 38 considers state to secure a social order for the promotion of welfare of the people. The state should also strive to promote the welfare of the people by securing and protecting as effectively as it may a social order in which justice, social, economic and political, shall inform all the institutions of the national life.

Article 39 requires the state to provide equal means of livelihood to all citizens. It also requires equal pay for equal work for both men and women.

Article 41 requires the state to make effective provision for securing the right to work, to education and to public assistance in case of unemployment, old age, sickness and disablement.

Article 42 require just and humane conditions of work and for maternity relief.

Article 43 imposes liability for the state to secure, by suitable legislation or economic organisation or in any other way, to all workers, agricultural, industrial or otherwise, work, a living wage, conditions of work ensuring a decent standard of life.

Above articles create accountability of the state for social security.

The social accountability is considered for the state and union governments to provide legal protection and welfare facilities for the organised and unorganised workers in India.

Most of the Labour Laws are for organised workers. Therefore Laws for social security are also needed for unorganised workers. See part II of this chapter.

Power lies with the government and there fore it is i its responsibility to provide various types of benefits to workers and public by the necessary Act and Rules as mentioned in this chapter. For workers ESI Act and Rules, WC Act and Rules, Maternity Benefit Act and Rules etc. are provided and for public PLI Act and Rules are provided. By virtue of these statutory provisions employers are responsible and accountable to provide above benefits to their workers otherwise they become accountable and answerable under above laws.

It is the duty of political parties, social organisations (NGO) and social institutions to help to the government or to provide independently social security to the workers and the public. Such benefits should be extended to the families of the workers also.

4 INDIAN LAWS ON SOCIAL SECURITY

Some Acts and Rules are as under :

1. Workmen's Compensation Act 1923, Rules 1924 (Transfer of Money) Rules 1935, and (Venue of Proceedings) Rules, 1996.
2. Employers' Liability Act 1938.
3. Mica Mines Labour Welfare Fund Act 1946.
4. Employees State Insurance Act 1948, (Central) Rules 1950 and (Central) Regulations 1950.
5. Employees Provident Funds and Miscellaneous Provisions Act 1952.
    (1) Employees Provident Fund Scheme, 1952.
    (2) Employees Family Pension Scheme, 1971.
    (3) Employees Deposit Linked Insurance Scheme, 1976.
6. Maternity Benefit Act 1961 (1995), State Rules and (Mines & Circus) Rules 1963.
7. Personal Injuries (Compensation Insurance) Act 1963, Scheme 1965 and Rules 1965.
8. Payment of Bonus Act, 1965.
9. Limestone and Dolomite Mines Labour Welfare Fund Act 1972 and (Amendment) Act 1982.
10. Payment of Gratuity Act 1972 and (Central) Rules 1972.
11. Iron Ore Mines Labour Welfare Fund Act 1976.
12. Beedi Workers Welfare Fund Act 1976.
13. Cine - Workers Welfare Fund Act 1981.

14. Child Labour (Prohibition and Regulation) Act, 1986 and Rules 1988.
15. Public Liability Insurance Act 1991 & Rules 1995.
16. Building and other Construction Workers Act, 1995 and rules 1998.

Some abstract of Sr. No. 1, 2 and 4 are given below. For details the statute books should be referred. See Chapters 27 and 28 also.

5 WORKMEN'S COMPENSATION ACT, RULES & WORKED EXAMPLES

5.1 Workmen's Compensation Act, 1923:

This Act (8 of 1923) came into force from 1-71924. It was lastly amended by the Act 46 of 2000 w.e.f. 08-12-2000. It has 4 chapters, 36 sections and 4 schedules. The Act is made to provide compensation for accidental injury to workmen. Under Sec. 4, while calculating compensation, maximum limit of 'monthly wages' to be considered is Rs. 4000/ - if monthly wages exceed Rs. 4000. Short summary is given below:

The Act extends to the whole of India. A list of 'dependants' is given u/s 2(1) (d).

Definitions (Sec. 2):

Definition of employer is very wide and includes his managing agent; legal representative of a deceased employer, contractor etc.

'Workmen' includes employees working in railway, ship, aircraft, motor vehicle, abroad or as in Schedule-11 wherein some 48 categories are specified.

''Wages' excludes travelling allowance or concession, special expenses and contribution towards any pension or P.P.

Partial disablement (temporary or permanent) and total disablement (temporary or permanent) are defined as same in the ESI Act and the W.C. Act. See part 7 also.

Employer's Liability (Sec 3) : He is liable to pay compensation if accident arises out of and in course of employment He is not liable for injury -

1. If disablement lasts less than 3 days
2. If the workman takes drink or drugs, or
3. Wilfully disobeys any order or a rule of safety, or
4. Wilfully removes or disregards any safety guard or device provided for his safety,

but he is liable even under such conditions if injury results in death or permanent total disablement.

If a workman contracts any occupational disease (i) in Part-A of Schedule III or (ii) in Part B of Schedule III if he is in continuous service of more than 6 months or (iii) in Part C of Schedule III if he is in the service of one or more employers for such continuous period as may be specified, it shall be deemed to be an injury by accident arisen out of and in course of the employment and makes the employer(s) liable for compensation. The disease should be directly attributable to his employment.

If a workman claims or agrees to take compensation under this Act, his suit for damages in a Civil Court is not maintainable [Sec 3(5)].

Amount of Compensation (Sec. 4) :

	Type of Injury		Amount
(a)	Death	50% of monthly wages X Relevant factor based on age (from Schedule IV) or Rs. 80,000/- whichever is more.	
(b)	Permanent total disablement	60% of monthly wages X Relevant factor from Schedule – IV or Rs. 90000/- whichever is more.	
(c)	Permanent partial disablement	1	For injury in part II of Schedule I, such % of compensation payable in item (b) above as % of loss of earning capacity mentioned in Column-3.
		2	For injury not specified in Schedule – J, such % of compensation payable in item (b) above as proportionate to the loss of earning capacity (permanent) certified by the medial practitioner.
(d)	Temporary disablement (total of partial)	Half monthly payment of the sum equivalent to 25% of monthly wages till the ceasing of the disablement or 5 years whichever is shorter.	

In case of death, the funeral expenditure of Rs. 2500/- shall be deposited with the Commissioner. Maximum limit of 'monthly wages' is Rs. 4000/- in above calculation. Compare Schedule I and III of W.C. Act, Schedule II and III of ESI Act and the Schedule of the Personal Injuries (Compensation Insurance) Act, 1963. They seem to be similar.

Penalty for late payment (Sec. 4A) :Compensation shall be paid as soon as it falls due. Jf it is paid after I month simple interest of 12% or maximum bank interest is payable. If delay is not justified, penalty up to 50% of the compensation is also payable.

A show-cause notice to the employer is necessary before passing an order for penalty.

The interest and penalty both shall be paid to the workman or his dependent, as the case may be.

Distribution of compensation (Sec. 8) : Compensation payable in case of death, payable to woman or legally disable (e.g. minor) person, shall be paid through Commissioner (Court) only and not directly. Direct payment shall not be deemed compensation.

An employer can give advance up to 3 months' wages which is deductible and the Commissioner shall repay it to the employer.

The Commissioner shall give receipt to the depositor, notice to dependant(s), make inquiry and if satisfied that no .dependant exists, he shall repay the balance to the employer. If the dependant is women or legally not eligible, the same may be investigated and mode of payment during non eligibility may be directed for the welfare. In other cases direct payment is possible. The Commissioner has power to change or amend his order for investment if satisfied with the reason.

Others : Method of calculating 'monthly wages' is prescribed u/s 5. Half monthly payment can be reviewed u/s 6 and converted into lump-sum u/s 7. Compensation is protected and cannot be assigned, attached or charged (sec. 9). Claim is to be made within 2 years (sec. 10). Delay may be justified. A Commissioner can directly send a notice to an employer to furnish within 30 days information of death of his workman or his explanation (sec IOA). Reports of fatal accident or serious bodily injury shall be given to the Commissioner within 7 days (sec. IOB). An injured workman will not refuse to undergo medical examination, otherwise his compensation may be suspended for the period of his refusal, or for the period of his return if he has left the premises without examination. In case of a contract labour, the principal employer is liable if the contractor fails to pay compensation (sec. 12). Where any employer has entered into any contract with any insurer for liability to a workman, the insurer will pay to the workman as per liability accepted. The workman has to give notice to the insurer for his claim as soon as he becomes aware that his employer has become unable to pay (sec. 14). Compensation can become first charge on assets transferred by employer (sec. 14-A). Prescribed return is to be sent to authority u/s 16. Any contract or agreement of relinquishing right of compensation is null and void u/s 17. Maximum penalty for offences is Rs. 5,000/-, Limit of filing complaint is 6 months and sanction of commissioner is necessary for prosecution (see ISA).

Special provisions are made for other workmen.

Chapter-3 (sec. 19 to 31) is regarding Commissioners, their appointment, venue, power, appearance of parties, evidence, registration of agreements, appeals, recovery etc.

Chapter-4 gives rule making powers to the State and procedure (sec. 32 to 36)

Schedule I to 4 are regarding (1) Injuries and loss of earning capacity, (2) List of different, 48, workmen (3) List of Occupational Diseases and (4) Age factors to calculate compensation, respectively.

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5.2 The Workmen's Compensation Rules, 1924 :

Under section 32 of the WC Act, these rules were notified on 26.6.1924.

Deposit of compensation (Rules 6 to 10) : In a death case the compensation shall be deposited with Form-A and in other cases with Form-AA. The receipt will be in Form-B. The statement of disbursements to be given to the employer (by commissioner) shall be in Form-C. A dependant's application for order to deposit compensation shall be in Form G.

Deposit u/s 8(2) i.e. any sum more than Rs. 10/shall be in Form-D and its receipt shall be in Form-E.

The Commissioner shall display a list of deposits received by him and invest for the benefit of dependants in Government securities or Post Office cash certificates or Post Office Savings Bank.

Reports of Accidents (Rules II &. 12) : Report of accident u/s IOB shall be in Form EE. An employer can present a memorandum of inquiry of any accident.

Medical Examination (Rule 13 to 18) : The employer shall arrange free of charge medical examination at his premises or at the workman's residence. Time will be between 6 a.m. to 7 p.m. if the workman does not consent to other time. A workman receiving half monthly payment will be examined at his residence and not more than twice in the first month or more than once in any subsequent month. After suspension of right to compensation, if the workman offers himself for examination, he shall be examined within 72 hours at the place and time fixed by the employer. Woman shall be examined by in presence of a female doctor.

Others : Chapters 5 to 8 are for procedure, transfer, appointment of representatives and memorandum of agreement (Forms K, L or M and notice to party in Form-0) respectively.

For figures of compensated injuries and amount of compensation paid under the WC Act see Table 5.11 of Chapter 5.

See IS'.3786 for injury rates and accident classification (Part 9 & 10 of Chapter 5).

Compensation for Occupational Diseases:

Compensation for occupational diseases is payable u/s 3 of the Workmen's Compensation Act, 1923. Subsections (2 to 4) provide as under :

1. Contracting of the disease peculiar to the employment and specified in Part A, B & C of Schedule III (mentioned in foregoing part 7.2.4) is to be considered as an injury by accident arisen out of and in the course of the employment.
2. For Part A diseases, compensation is payable irrespective of any length of service as the incidence rate or possibility of such diseases is high and very obvious.
3. For Part B diseases, compensation is payable provided a service of 6 months is completed, as these diseases are very specific to certain chemicals and their incidence rate is slightly lower than that of Part A diseases.
4. For Part C diseases, compensation is payable, irrespective of length of service and even if the affected worker has worked under one or more employers, as these are lung diseases and their effect is delayed i.e. visible after 5 to 10 years of service.
5. Compensation is payable for Part B & C diseases even after the cessation of the service.
6. For Part C diseases and for working under more than one employer, all the employers are liable to pay compensation in proportions decided by the W.C. Commissioner.
7. For any other disease, if it is directly attributable to a specific injury by accident arising out of and in the course of employment, the compensation is payable.
8. Compensation is not payable if any suit for damages is filed in the court or a suit for damages shall not be maintainable if a claim for compensation is filed before the W.C. Commissioner, or if any agreement is made between the workman and his employer to pay in accordance with the WC Act.
9. The doctor shall refer Schedule I while assessing percentage loss of earning capacity.
10. The maximum period of half-monthly payment for temporary disablement is 5 years, and wage limit of Rs. 4000 is not applicable in this case.

5.3 Worked Examples :

Section 4 and Schedule I, III and IV are to be seen simultaneously. Monthly wage limit is Rs. 4000.

For example, if death occurs due to any disease mentioned in Sch. Ill, payment should be as per section 4 (1) (a).

Example I : A worker of 24 years (completed) and drawing monthly wages of Rs. 3800, dies due to any disease mentioned in Part A or C or any disease in Part B if his service is of more than 6. months, amount of compensation shall be
= 0.50 x 3800 x 218.47 (Age factor)
= 1900 x 218.47 = Rs. 4,15,093 or Rs. 8,000 whichever is more..

Note : If monthly wages are more than Rs. 4000 per month, consider Rs. 4000/- only for the purpose of calculation. Age factor is derived from Schedule IV based on completed years of age.

Example 2 : A worker gets any of the permanent total disablement mentioned in Part I of Sch. I, due to occupational disease in Part III, and his age and monthly wages are 48 and Rs. 5600 respectively. Compensation will be
= 0.60 x 4000 x 159.80
= 2400 x 159.80 = Rs. 3,83,520 or Rs. 90000 whichever is more.

Example 3 : A worker loses partial vision of one eye (item 26A, part II, Sch. 1) due to occupational cataract by infrared radiation (item II, Part B, Sch. Ill) at the completed age of 40 with monthly wages Rs. 6500. Compensation shall be
= 0.10 x 4000 x 184.17
= 400 x 184.17 = Rs. 73668.

Example 4 : A worker suffering from silicosis (e.g. any lung disease) - injury not specified in Sch. I, but certified by a doctor as '80% loss of earning capacity (permanent partial disablement)' at his age of 58 and monthly wages Rs. 9600, his compensation shall be

= 0.80 x 4000 x 124.70
= 3200 x 124.70 = Rs. 3,99,040.

Example 5 : A worker's whole middle finger is amputated (item 31, Part II, Sch. 1) due to chrome ulceration and his lung damaged by 30% permanent partial disablement as assessed by the doctor, due to exposure to chromium vapours, and his age and monthly wages being 38 and Rs. 5600 respectively, his compensation shall be -

(1) For finger damage
= 0.12 x 4000 x 189.56
= 480 x 189.56 = Rs. 90988.80

(2) For lung damage
= 0.30 x 4000 x 189.56
= 1200 x 189.56 = Rs. 2,27,472

Total Rs. 90988.80 + 227472.00
= Rs. 3,18,460.80

Comparing with permanent total disablement [Sec 4(1) (C), Explanation - 1]

= 0.60 x 4000 x 189.56
= 2400 x 189.56 = Rs. 4,54,944 or Rs. 90000
whichever is more.

As amount Rs. 318460.80 does not exceed Rs. 454944, total compensation payable in this case is Rs. 318460.80.

Example 6 : A worker worked in three sugar mills in a continuous period of 16 years and it was detected that he was suffering from bagassosis due to sugarcane dust. This was found at his age of 45 and monthly wages Rs. 7800. The lung damage (permanent partial disablement) assessed by a doctor is 50%. Calculate the compensation payable by each, of the three employers.

Compensation
= 0.50 x 4000 x 169.44
= 2000 x 169.44 = Rs. 338880

As per Section (2-A), each employer may pay Rs. 338880/3 = Rs. 112960 to the worker, or in the proportion decided by the WC Commissioner depending on the facts of his case. The employer in whose sugarmill suppose the dust concentration was higher or for longer duration, may be directed by the Court to pay more proportion of the total amount.

Example 7 : A worker while handling organo phosphorous compound, undergoes toxic effect and remains absent for 3 months as per medical finding of this cause and advice. To what compensation he is entitled for this temporary disablement? He is drawing Rs. 4500 per month.

As per Section 4 (1) (d), he is entitled to a half monthly payment of 25% of his monthly wages i.e.. 0.25 x 4500 = Rs. 1125 from the 16th day from the date of disablement.

Here ceiling of Rs. 4000 per month is not applicable. It is applicable to death or permanent total disablement only [Explanation II to Sec 4 (1)].

6 EMPLOYERS' LIABILITY ACT, 1938

This Act (24 of 1938) came into force from 249-1938. It was lastly amended by an Act 51 of 1970. It is a small Act of five sections only. Its preamble declares that certain defences shall not be raised in suits for damages in respect of injuries sustained by workmen.

It extents to the whole of India and applies to all employers including contractors and agents who employ workmen-(including apprentice) under a contract which is express or implied.

Defence of common employment barred : Where personal injury is caused to a workmen because of the act or negligence or omission of the employer or of any person in service of the employer and acting in obedience or performing duty by the workman, a suit for damages by the injured workman or by his legal representative in case of his death, shall not fail by reason only of the fact that the workman was in the service (duty bound to do so and in common employment or he has accepted that risk) of the employer at that time.

Any term in contract of service or apprenticeship that excludes or limits liability of the employer in respect of personal injury caused to the workmen or apprentice by the negligence of persons in common employment with him, shall be void.

In any such suit for damages, it shall not be presumed that the workman undertook the risk attaching to the employment unless the employer proves that the risk was fully explained to and understood by the workman and that the workman voluntarily undertook the same.

This Act gives support to the claim (damages) of the worker in civil suits. Plea of the employer of 'contributory negligence by the worker or his knowingly acceptance of the risk as an integral part of his employment' is prohibited and this defence is not permitted for him. Though after fully amending ESI Act and WC Act and covering large scope of injuries and compensation, utility of this Act is diminished.

7 EMPLOYEES' STATE INSURANCE ACT & RULES

7.1 The Employees' State Insurance Act, 1948 :

This Act No. 34 of 1948 (in force from 31-31948) was modified in 1950,1956 and 1957 and amended in 1951, 1966, 1970,1975,1984 and 1989. It has 8 Chapters, 100 Sections and 2 Schedules. Chapter 4 of contributions and Chapter 5 of Benefits are more important.

Preliminary (Sec. 1) : The Act applies to the whole of India and to all factories other than seasonal factories. It can be applied to establishment industrial, commercial, agricultural or otherwise with six months' notice. Once the Act applies it shall continue even if the number of employees falls below the limit or the manufacturing process (with power) ceases.

Definitions (Sec. 2) : Contribution means the sum of money payable to the ESI Corporation by the principal employer in respect of an employee and an amount payable by or on behalf of the employee.

Dependent includes many relatives as prescribed by Sec.2 (6-A).

Employment injury means an injury to employee caused by accident or occupational disease arising out of and in course of his employment (insurable) whether the accident or disease takes place within or outside India.

Employee includes direct, contract or hired persons at main factory or establishment or its department, branch or a place for sale/purchase and also an apprentice (not under the Apprentices Act, 1961). His wage limit (excluding overtime wages) be prescribed by the Central Government.

Family is defined u/s 2(11)

Permanent partial disablement means such disablement of a permanent nature as reduces the earning capacity of an employee in every employment which he was capable of undertaking at the time of the accident resulting in the disablement (All injuries in Part II of the 2nd Schedule). .

Permanent total disablement means such disablement of a permanent nature as incapacitates an employee for all work which he was capable of performing at the time of the accident resulting in such disablement (All injuries in Part I of the 2nd schedule or from combination of injuries in Part II thereof).

Temporary disablement means a condition which requires medical treatment and makes the employee temporarily incapable of doing the work which he was doing prior to the time of injury.

Wages includes all remuneration except contribution to any pension fund or provident fund or under this Act, travelling allowance, gratuity and special expenses.

Corporation's Power for Health Measures (Sec. 19) : The Corporation may, in addition to the scheme of benefits, promote measures for the improvement of health and welfare, rehabilitation and reemployment of insured persons from the funds of the Corporation.

Purposes of the ESI Fund (Sec. 28) :

1. Payment of benefits and medical treatment to insured persons and their families.
2. Expenditure of hospitals, dispensaries, medical and ancillary services for the insured persons and their families.
3. Contribution to State Govt., local authority or any private body or individual towards cost of medical treatment to insured persons and their families, including cost of building and equipment.

4. Expenditure for improvement of health, welfare, rehabilitation and re-employment of insured or injured persons.
5. Payment of fees, salaries, allowances of the members, officers and staff.
6. Payment of cost of auditing accounts, courts set up under the Act, contract and cost of any legal or court proceedings.

Contributions (Chapter-4, Sec. 38 to 45-1) : Two types (i) Employer's contribution and (ii) Employee's contribution. Rates may be prescribed by the Central Government. Payment becomes due on the last day of the wage period. Interest 12% p.a. or more for the late payments. It is recoverable as an arrears of land revenue. The principal employer shall pay both the contributions and can recover from the employees or their immediate employer (e.g. contractor) their part. Register of- employees, contributions necessary and returns are also required.

ESI Inspectors have powers to visit factories, establishments etc. and to ask any principal or immediate employer to furnish necessary information, account books, records etc. regarding employment of persons, payment of wages etc. and can make copies also for the purposes of this Act.

Benefits (Chapter-5, Sec. 46 to 73 1) : Insured persons, their dependants or other persons mentioned can get following benefits under the Act and no similar benefits under any other Act. Though they can get similar benefits available under service conditions, customary concession, sickness leave, motor accident claims under the Motor Vehicles Act and damages/compensation for injuries due to the negligence of the employer (Judgements).

1. Sickness benefit : Periodical payments for sickness certified by a Doctor. Eligibility, rates and conditions may be prescribed by the Central Government.

2. Maternity Benefit : Periodical payments to an insured woman in case of confinement, misscarriage, sickness due to pregnancy, premature birth etc. on medical certificate. Eligibility, rates, period and conditions may be prescribed by the Central Government.

3. Disablement benefit : Periodical payment to an insured person for disablement due to employment injury and certified by a doctor.

   (a) For temporary disablement of more than 3 days (excluding the day of accident) and
   (b) For permanent disablement - total or partial - this benefit is available at the rate, period and condition prescribed by the Central Government.

   An accident shall be presumed as arisen in course of employment, in the absence of evidence to the contrary. Benefit is available for accident happening while acting inbreach of regulation or while travelling in employer's transport or while meeting emergency and acting for the employer's trade or business.

4. Dependants' benefit : Periodical payments to the dependants of an insured person who dies due to employment injury. The rates, period and conditions may be prescribed by the Central Government.

5. Medical benefit : Payment for medical, surgical and obstetric treatment for and attendance on insured persons, by the State Government or the Corporation.

6. Funeral expenses.: Payment to the family member or any other person who actually incurs expenditure on the funeral of the deceased insured person. i.

The claims should be made within 3 months of the death of the insured person.

Occupational Disease as an Employment injury : Contracting of any disease mentioned in the Third Schedule and in its

Part A -without any period in that employment,
Part B - for working more than 6 months in that employment, or
Part C -for working such period as the Corporation specifies,

Shall be deemed to be an "Employment injury arising out of and in the course of employment".

Any question regarding permanent disablement or proportion of loss of earning capacity or any such assessment, shall be determined by a Medical Board. An appeal against the decision of the medical board may lie with the Medical Appeal Tribunal. Both the Board and the Tribunal can review their decisions if satisfied by fresh evidence.

The corporation may, with the approval of the State Government, establish and maintain in the State hospitals, dispensaries, medical and surgical services for the benefit of the insured persons and their families.

The right to receive any payment of any benefit is not transferable or assignable. Disablement benefit cannot be commuted for a lump sum amount.

Sickness or disablement benefit for temporary disablement cannot be availed if the employee works on that day (of claim) or remains on leave or on a paid holiday or on strike.

Recipient of sickness or disablement benefit will observe conditions to remain under medical treatment at a place provided under this Act, to carry out medical instructions, not to leave the area, to allow himself for medical examination and not to do anything which may retard chances of recovery.

An insured person cannot get for the same period (a) both sickness and maternity benefit or (b) both sickness and temporary disablement benefit or (c) both maternity and temporary disablement benefit. When a person is entitled to more than one such benefits, he has to choose any one benefit.

The corporation has right to recover where a principal employer fails or neglects to pay any contribution, or any amount for excessive sickness arised due to in sanitary working conditions or not observing any health regulations.

If any person receives any benefit unlawfully, he shall be liable to repay to the corporation that amount.

If any person dies, any cash benefit payable to him shall be paid to his nominee/representative upto and including the day of his death.

No employer can reduce wages or benefits payable by him under service conditions because of the benefits conferred by this Act.

No employer can dismiss or punish employee during period of sickness, maternity, temporary disablement or certified illness etc. Notice of dismissal, discharge or reduction during such period shall be invalid or inoperative.

A person who misuses the benefit given under this Act, will be disentitled by the Central Government after giving him an opportunity of being heard.

Miscellaneous (Sec. 87 to 100) : The Government has power of exemptions. Rule making powers lies with the Central as well as the State Governments. The Corporation has power to make regulations. For their subjects see sections 95 to 97.

7.2 The Employees' State Insurance (Central) Rules 1950 :

They came into force from 22-6-1950. The Chapter-6, sections 47 to 62 are important as they provide further details on the subject of provident fund, wage limit, rates of contribution and benefits. Their summary is as under:

P.F. : The Corporation shall establish, maintain, and contribute to the "ESIC Provident Fund" for insured employees. It shall form a committee and regulations for its working.

Contribution period and Benefit period :

They are prescribed as under :

Contribution Period	Corresponding Benefit Period
1st April to 30th Sept.	1st January to 30th June of the year following
1st Oct. to 31st March of the year following	1st July to 31st December

Incase of a person who becomes an employee for the first time, the first contribution period for him will begin from the date he enters into insurable employment in the contribution period current on that day (i.e. the date of employment) and his corresponding benefit period will begin on the expiry of nine months from the date of such employment.

Wage Limit for Coverage : Up to Rs. 10000/ - p.m. w.e.f. 1-4-2006.

Rates of Contribution : Employer's contribution 4.75% of the wages payable to an employee. Employee's contribution 1.75% of his wages (w.e.f. 11-1997). An employee whose average daily wage is upto Rs. 50/- is exempted from paying his contribution though the employer's contribution in respect of such employee, shall continue (News, 7-9-97).

Standard benefit rate : As per Table, u/r 54. Revised with 18 entries w.e.f. 1-1-1997.

Sickness benefit : It is available if the contribution is paid for 50% of days of the contribution period. For the first two days of sickness the benefit is not available. For maximum 91 days in any two consecutive period the benefit can be available. Payment rate is the standard benefit rate u/r 54.

Maternity benefit: At least 70 days contribution during preceding two consecutive contribution periods make the insured women eligible for this benefit. For maximum 12 weeks the benefit is available. Medical proof is necessary. Payment rate is twice the 'standard benefit rate' u/r 54.

Disablement benefit: It is available for the disablement period of more than 3 days (excluding the day of accident) and for the whole period of permanent disablement or for life. Daily rate of payment shall be 40% more than the standard benefit rate u/r 54, and this rate shall be called the "full rate". For temporary and permanent total disablement, full rate is available, but for permanent partial disablement from injury specified in Part II of the 2nd schedule, at such percentage of the full rate and for injury not specified in that schedule, at proportionate to the loss of earning capacity (assessed by the medical certificate) the benefit will be available.

Dependants" benefit: To widow 3/5 of the full rate (till life or remarriage), to son 2/5 of the full rate (until he attains 18 years age), to unmarried daughter 2/5th of the full rate (until the age of 18 years or marriage whichever is earlier). If no widow or children, then, to a parent or grand parent for life 3/ 10 of the full rate, to any other male dependent till his age of 18 and to any other female dependent till the age of 18 or marriage, whichever is earlier or if widowed, until her age of,18 or remarriage whichever is earlier at 2/10 ofthe full rate. Total rate shall not exceed full rate and the amount shall be equally divided among the dependants.

Funeral expenses: Rs. 2500/- from 1-10-2001.

7.3 The Employees' State Insurance (General) Regulations, 1950 :

The corporation has made u/s 97, these regulations, w.e.f. 17-10-1950 to provide further details. Some summary is given below:

Provisions of identity card, family identity care Inspector, Insurance Medical Officer, Insurance Number, local office, regional office, regional director local committees are explained.

Registration of factories, establishments and families is required. Return of contributions, in Form No. 6, in 4 copies is to be sent to the ESI office Contributions should be paid within 21 days of the last day of the month in which it fall due. In case of permanent closure, it should be paid on the last. day of closure. For late payment, interest at 15% p.a is payable. In addition to this, damages are also payable as under:

No.	Delay Period	% P.A. damages
1.	Upto 2 months	3
2.	2 to 4 months	10
3.	4 to 6 months	15
4.	6 months and above	25

Register of employees should be in Form-7.

Benefits (Chapter 3, Regulation 44 to 95E) : For any benefit, proper claim form should be filled in Claim becomes due from the date of medical certificate and it shall be certified by the Local Office, which can ask further evidence also. Medical certificate from Insurance Medical Officer is necessary.

Benefits (first payment) are payable as under

No.	Type	To be paid within
1.	Sickness benefits	7 days
2.	Funeral expenses	15 days
3.	Maternity benefit	14 days
4.	Temporary disablement	30 days
5.	Permanent disablement	30 days
6.	Dependant’s benefit	90 days

Disablement Benefit : An employee will inform employer about accident to him. Employer will record it in an Accident Book in Form No. 15 and will report to die Local Office in Form No. 16 within 24 hours. For occupational disease specified in 3rd schedule no such notice is necessary but information required by the Local Office shall be given. Employer shall arrange for the first aid.

Dependants benefit : Death of an insured person is to be reported immediately to the Local Office and his body shall be disposed of 'after examination (and post-mortem if necessary) by Insurance Medical Officer or other Medical Officer. Death certificate in Form 17 shall be issued to the dependants. Claim for dependants' benefit will be submitted in Form 18 to the Local Office, with documents and proofs prescribed u/r 80.

Maternity Benefit : An insured woman will give notice in Form 19 and pregnancy certificate in Form 20 to the Local Office. Other Forms 21, 22, 23 are also required as per Reg. 88. She may loose benefit if refuse for medical examination by a female doctor or midwife.

Funeral expenses: Death certificate in Form 15 and claim Form 25-A are prescribed.

Medical benefit : A person receiving disablement benefit can also get medical benefit. This benefit is available after payment of contributions for 50% days of the contribution period and for a period of 3 months if he is continued in the service for 2 months or more.

Some 28 forms have been prescribed under these Regulations.

For .figures of number of factories and employees covered and benefits given under the ES. Act see Table 5.13 and 5.14 of Chapter-5.

Criticism : This ESI scheme logically and theoretically seems beneficial for well being of the workers but in its practice of more than 45 years it has gained heavy criticism because of its

1. Poor administration.
2. Incapacity to provide speedy service to thousands of workers and their families.
3. Insufficient hospitals, dispensaries, doctors, facilities and staff.
4. Rude and rigid behaviour with workers who need love and affection.
5. Complexity of forms and procedure.
6. Hardship to workers in going to limited centres and at a longer distance.
7. Poor quality of medicines and treatment.
8. No real interest in worker's welfare 'and referring him here and there.
9. More stress in collecting money than 'disbursement of benefits to workers.
10. Profit making attitude instead of charitable.

Because or above factors not only employers out employees and their trade unions have also opposed this scheme and resisted against its forceful application. Insured employees prefer to go to private doctors and hospitals for better treatment. They are loosing faith from ESI doctors, their treatment and medicines. Only poorer workers go there under compulsion.

As per one news report of 25-8-1997, even after raising the eligibility wage limit from. Rs. 3500 to Rs. 6500 per month and similar increase in employers' contributions there is no improvement in ESI medical services. On the contrary the condition is deteriorated. Despite of increase in number of employees and income of the Scheme, strength of doctors is reduced. In 1995 there were 3160 doctors which reduced to 3076 in 1996. In 1991 there was, one doctor per 2127 members While in 1996 that proportion was one doctor per 2374 members! The Government gives subsidy also. Even then the service is not satisfactory.

It is suggested in this report that the Government should give Health Insurance Policies to the members to make the Scheme more meaningful.

In another press-note of Financial Express dated 4-9-97, it is confessed that many States are giving less importance to the Scheme and the Corporation has become a silent spectator and the quality of the Scheme has gone down. The Central Administration is unable to pay full attention and therefore it is, now, decided to establish State Corporations under the control of the Central ESI Corporation.

Where ESI scheme is made applicable, a trend is noticed of increase in accidents. This may be due to a wrong approach of workers' to take benefit of accident leaves. This again adds to the loss of national production.

ESI authorities and corporation has to find and apply remedial measures to above problems.

Expansion of infrastructure, HRD training to doctors and staff, loving and charitable attitude, less contribution and higher benefit utilising full income, better hospitals, nice dispensaries, good facilities and speedy service can certainly change its present scenario.

8 THE GUJARAT PAYMENT OF UNEMPLOYMENT ALLOWANCE TO WORKMEN IN FACTORIES ACT, 1981

This Gujarat Act (No. 20 of 1981) received the President's assent on 28-5-1981. It is applicable to the State of Gujarat.

Enrolled workmen (including Badli, permanent or temporary workman) shall be paid unemployment allowance, at the rate of 50% of basic wages plus dearness allowance, for the days for which an employer fails, refuses or is unable to provide employment to them, during the specified period notified by the State Government from time to time in the Official Gazette, by reason of any restriction on consumption, use or supply of electrical energy to the factory.

Workman is not entitled to such allowance if he is entitled to any lay-off compensation or if he refuses to accept any alternative employment in the same factory.

9 GUJARAT PHYSICALLY HANDICAPPED PERSONS (EMPLOYMENT IN FACTORIES) ACT AND RULES

9.1 The Gujarat Physically Handicapped Persons Act, 1982 :

This Act received the assent of the President on 19-2-1982 and applied to the State of Gujarat from 710-1981 It has 14 sections

It is applicable to every factory employing 100 (Notification dated 7-5-2004) or more workers. A factory belonging to or managed by the Central Government is excluded. Once applied, it remains applied even if the number of workers falls below 100.

'Certifying Surgeon' and Inspector' means those appointed under the Factories Act, 1948.

'Physically handicapped person' is defined as a person who, on account of any deficiency, injury, disease or congenital deformity, is substantially handicapped in obtaining or keeping employment, or in undertaking work on his own account, of a kind which for such deficiency, injury, disease or deformity would be suited to his age, experience and qualifications. '

One percent vacancies are to be allocated for and filled in by such handicapped persons registered with an employment exchange. (S.3).

Vacancies shall be allocated for handicapped persons and it shall not be filled-in by any person other than the handicapped person. (S.3).

The handicapped person must be an adult, registered with the State Employment Exchange and having a certificate of fitness (S.4) granted by a Certifying Surgeon in Form 1. (S.5). The CS should have personal knowledge of the place and process where the physically handicapped person is to be employed.

The employer shall keep a register of such persons in Form II.

Sections 7 to 14 provide for powers of Inspectors, penalties, rule making power etc.

9.2 The Gujarat Physically Handicapped Persons (Employment in Factories) Rules, 1982 :

By Notification dated 25-2-1983, of the Labour & Employment Department, the Government of Gujarat made these rules u/s 13 of the above Act.

Rule 2 defines blind, deaf, deaf and mute, functional capacity, orthopedically handi-capped etc.

Following three Forms are prescribed by these rules:

Form I	-	Certificate of fitness to a Physically Handicapped person.
Form II	-	Register of Handicapped workers.
Form III	-	Requisition of vacancies to the Employment Exchange.

Half yearly reports standing on 1st January and 1st July are to be sent in Form II, within I month after these periods.

10 PUBLIC LIABILITY INSURANCE ACT AND RULES

10.1 Public Liability Insurance Act, 1991:

This Act (No.6 of 1991) was enacted on 22-11991 and came into 'force from 23-1-1991. As mentioned in its preamble, the Act provides for public liability insurance for immediate relief to persons affected by accident occurring while handling any hazardous substance and for matters connected therewith. The Act has 23 sections.

The statement of objects and Reasons in drafting the bill is reproduced below :

The growth of hazardous industries, processes and operations in India has been accompanied by the growing risks from accidents not only to the workmen employed in such undertakings, but also innocent members of the public who may be in the vicinity. Such accidents lead to death and injury to human beings and other living beings and damage private and public properties. Very often, the majority of the people affected are from the economically weaker sections and suffer great hardships because of delayed relief and compensation. While workers and employees of hazardous installations are protected under separate laws, members of the public are not assured of any relief except through long legal processes. Industrial units seldom have the willingness to readily compensate the victims of accidents and the only remedy now available for the victims is to go through prolonged litigation in a Court of Law. Some units may not have the financial resources to provide even minimum relief.

It is felt essential, therefore, to provide for mandatory public liability insurance for installations handling hazardous substances to provide minimum relief to the victims. Such an insurance apart from safeguarding the interests of the victims of accidents would also provide cover and enable the industry to discharge its liability to settle large claims arising out of major accidents. If the objective of providing immediate relief is to be achieved, the mandatory public liability insurance should be on the principle of "no fault" liability as it is limited to only relief on a limited scale. However, availability of immediate relief would not prevent the victims to go to courts for claiming larger compensation.

The Bill seeks to achieve the above objectives.

Definitions (S. 2):

Accident means an accident involving a fortuitous or sudden or unintended occurrence while handling any hazardous substance resulting in continuous or intermittent or repeated exposure to death of, or injury to, any person or damage to any property but does not include an accident by reason only of war or radioactivity.

Handling of hazardous substance means the manufacture, processing, treatment, package, storage, transportation by vehicle, use, collection, destruction conversion, offering for sale, transfer or the like of such hazardous substance, (vehicle means any mode of surface transport excluding railways).

See also S. 2(d) of the EP Act.

Hazardous substance means any substance or preparation which is defined u/s 2 (e) of the EP Act and exceeding such quantity notified by the Central Govt.

Liability of Owner:

Every owner shall take, before he starts handling of any hazardous substance, one or more insurance polices to ensure himself against liability to give relief as specified in the schedule given below to any person (other than a workmen, as defined in WC Act) who suffered injury, death or property damage due to any accident. The policy shall be kept renewed. It shall be for an amount more than the paid-up capital or the market value of all assets and stocks, but not exceeding 50 crore rupees. In addition to this, the owner shall also pay to the insurer, together with the amount of premium, further amount, not exceeding the premium and as may be prescribed to be credited to the Relief Fund u/s 7-A. The insurer shall remit this amount to the authority in S. 7-A within a prescribed time.

Schedule of Threshold quantities of Hazardous substance :

U/S 2(d) of the PLI Act, a schedule is notified of hazardous substances. Liability of PLI policy arises if hazardous substances are handled in quantity equal to or more than tins threshold quantity.

For the names and quantities of these hazardous substances, (179 and more) the schedule should be reffered. \Threshold quantities of some of these substances are given below from the schedule.

No.	Name of hazardous substance	Quantity
1	Arsine (Arsenic hydride)	10 kg
2	Benzidine	1 kg
3	Mthyl isocynate	150 kg
4	Phosgene (Hydrogen phosphide)	750 kg
5	Acrylonitrile	20 t
6	Ammonia	50 t
7	Bromin	40 t
8	Carbon disulphide	20 t
9	Chlorine	10 t
10	Ethylene dibromide	5 t
11	Formaldehyde (concentration < 90%)	5 t
12	Hydrogen chloride (liquefied gas)	25 t
13.	Hydrogen cynide	5 t
14.	Hydrogen fluoride	5 t
15.	Sulphur dioxide	20 t
16.	Sulphur trioxide	15 t
17	Acetylene	5 t
18	Ethylene oxide	5 t
19	Hydrogen	2 t
20	Liquid Oxygen	200 t
21	Nitroglycerine	10 t
22	Trinitrobenzene	50 t
23.	**Flammable gases** (substances which in the gaseous state normal pressure and mixed with air become flammable and the boiling point of which at normal pressure is 20°C or below;)	15 t
24.	**Highly flammable liquids** Substances which have a flash point lower than 21°C and the boiling point of which at normal pressure is above 20°C.	1000 t
25.	**Flammable liquids** Substances which have a flash point lower than 55oC and which remain liquid under pressure, where particular processing conditions, such as high pressure and high temperature, may create major accident hazards.	25 t

Schedule of Relief

1. Reimbursement of medical expenses upto Rs. 12,500 in each case.
2. For fatal accident Rs. 25,000 per person in addition to (1) above.
3. For permanent total or partial disability, injury or sickness, reimbursement of medical expenses upto Rs. 12,500 and cash relief based on percentage disablement certified by an authorised doctor, the relief for total permanent disability being Rs. 25,000.
4. For loss of wages due to disability Rs. 1000 per month upto 3 months provided the victim is above 16 years and hospitalised for at least 3 days. (S. 3 & 4).
5. Upto Rs. 6000, for damage to private property.

Relief Procedure :

The Collector shall verify the occurrence of an accident in his jurisdiction and cause publicity for inviting relief applications (S. 5). Application (in Form 1) shall be made to the Collector within 5 years of the accident. The Collector shall hold inquiry and give award of relief within 3 months of the receipt of relief application. The insurer or/and owner shall deposit the amount as directed by the Collector, within 30 days of the award. The Collector shall arrange to pay from the Environment Relief Fund established by notification of the Central Govt. In addition to relief under this Act, right to get compensation under any other law is also maintainable but in that case the owner has right to reduce (deduct) the amount paid as relief under this Act (S. 5 to 8).

Other provisions:

The Central Govt. can authorise any person to ascertain requirements of this Act and that person shall have a right of entry and inspection, search and seizure, removing hazardous substance at the cost of its owner (S. 9 to II), the Central Govt. has power to give directions to any person, officer, authority, agency etc. including the direction to prohibit or regulate the handling of hazardous substance or to stop or regulate electricity, water or any other service (s. 12), the Central Govt. or the authorised person can apply to Court for restraining owner from handling hazardous substance and in that case the Court may direct the owner to desist from such handling or authorise the applicant to implement the direction at the cost of the owner (S. 13).

Provisions are also made for offences by companies (S.16), offences by Govt. Departments (S.17), cognisance of offence by the authority or by any person who gives notice of at least 60 days of his intention to complain about the alleged offence, before the authority (S.18), power to delegate (S.19), protection of action in good faith (S.20), advisory committee (S.21), this Act has effect despite anything inconsistent therewith (S.22) and rule making power of the Central Govt. (S.23).

10.2 Public Liability Insurance Rules 1991 :

The Central Govt. u/s 23 of the Public Liability Insurance Act made these rules which came into force on 1-5-1991. They have II rules and 2 Forms. Their abstract is as under :

A relief application shall be made to the Collector in Form-1 (R.3) accompanying the relevant documents such as disability/illness certificate from an authorised physician, death and/or post-mortem certificate, birth or age certificate, proof of hospitalisation for more than 3 days, employers certificate for loss of wages, medical bills and receipts, repairing or replacement cost certificate regarding damaged property etc. (R.4).

The Collector has all the powers as prescribed in Rule 5 and shall maintain a register of claim applications, awards and payment made, shall keep it open for public and give copy on request (R.7).

All directions u/s 12 shall be in writing, the objections may or may not be invited and the proposed action may be confirmed, modified or withdrawn and the notice may be served as prescribed (R.8).

For cognisance of offence u/s 18, notice in Form-11 shall be sent to the authorities mentioned in R9.

Maximum liability of the insurer to pay relief is Rs. 5 crores (to several claimants) in case of one accident and Rs. 15 crores in case of more accidents during one year or the period of policy whichever is less. If the award amount exceeds this limit, it shall be met with from -the relief fund and in case it still falls short, the balance amount shall be payable by the owner. (R. 10).

Owner's contribution to the Environmental Relief Fund shall be equal to the premium payable to the insurer and it shall be paid alongwith the premium to the insurer. The contribution so received shall be remitted as per the scheme u/s 7-A.

Form - 1: Application for compensation (claim).

Form - II : Notice for cognisance of offence.

11. NATIONAL ENVIRONMENT TRIBUNAL ACT, 1995 :

The introductory words explaining the need of this Act are as under :

The protection and improvement of the Human Environment is a major issue which affects the wellbeing of people and economic development throughout the world; it is the urgent desire of the people of the whole world and the duty of all governments. There is growing evidence of man-made harm in many regions of the earth; dangerous levels of pollution in air, water, earth and living beings thereon, major and undesirable disturbances to the ecological balance of the biosphere; destruction and • depletion of irreplaceable resources; and gross deficiencies harmful to the physical, mental and social wealth of man, in the man-made environment, particularly in the living and working environment.

Statement of Objects & Reasons in passing this Act is reproduced below :

The principle of strict civil liability in accident cases arising from the activities involving hazardous substances has been highlighted in a case by the Supreme Court of India. An enterprise engaged in activities with potential threat to the health and safety of the persons residing in the surrounding areas of the factory owes an absolute duty to the community to ensure that no harm is caused to any one on account of hazardous and inherently dangerous nature of such activities. Cases seeking compensation for damages to human health, property and the environment, particularly contamination of sub-surface water, are increasing. There is also an increasing trend in the number of industrial disasters.

The United Nations Conference on Environment and Development held at Rio de Janeiro in June, 1992, in which India participated, has also called upon the States to develop National laws regarding liability and compensation for the victims of pollution and. other environmental damage.

It is deemed expedient to develop and codify the principle of strict civil liability in respect of all such cases where damage is caused while handling hazardous substances. It is proposed to establish a National Environment Tribunal for effective and expeditious disposal of cases arising from certain industrial accidents and disasters with a view to providing effective and expeditious relief and compensation for damages to human health, property and the environment.

The Bill seeks to achieve the aforesaid objects.

The Bill introduced in 1992 was passed by both the Houses of the Parliament in 1995, and received the assent of the President on 17th June, 1995 and became an Act of Parliament under the short title "The National Environment Tribunal Act, 1995 (29 of 1995)".

Preamble of the Act provides for strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expeditious disposal of cases arising from such accident, with a view to giving relief and compensation for damages to persons, property and the environment and for matters connected therewith or incidental thereto.

The Act has 5 chapters, 31 sections and a Schedule..

The words 'accident', 'handling' and 'hazardous substance' are defined as the same as defined u/s 2 of the Public Liability Insurance Act, 1991 and the word 'environment' is defined as the same as defined u/s 2 of the Environment (Protection) Act 1986 (see Part 10.5 of Chapter-28).

'Tribunal' means the National Environment Tribunal established u/s 8 by the Central Govt.

Liability to Pay (5.3) :

The Schedule u/s 3(1) gives following heads under which compensation can be claimed by any person (other than a workman) for death, injury or damage to property or environment :

1. Death;
2. Permanent, temporary, total or partial disability or other injury or sickness;
3. Loss of wages due to total or partial disability or permanent or temporary disability;
4. Medical expenses incurred for treatment of injuries or sickness;
5. Damages to private property;
6. Expenses incurred by the Government of any local authority in providing relief, aid and rehabilitation to the affected persons;
7. Expenses incurred by the Government for any administrative or legal action or to cope with any harm or damage, including compensation of environmental degradation and restoration of the duality of environment;
8. Loss to Government or local authority arising out of, or connected with the activity causing any damage;
9. Claims on account of any harm, damage or destruction to the fauna including milch and draught animals and aquatic fauna;
10. Claims on account of any harm, damage or destruction to flora including aquatic flora, crops, vegetables, trees and orchards;
11. Claims including cost of restoration on account of any harm or damage to environment including pollution of soil, air, water, land and eco-systems;
12. Loss and destruction of any property other than private property;
13. Loss of business of employment or both;
14. Any other claim arising out of, or connected with, any activity of handling of hazardous substance.

In claiming above compensation, the claimant needs not to prove any wrongful act, neglect or default of any person.

If the injury is due to several activities, operations and processes, the Tribunal may apportion the liability for compensation amongst those responsible for such activities on an equitable basis.

Application for Claim (S.4) :

The person who has sustained the injury, the owner whose property is damaged, legal representative of the deceased, duly authorised agent, any organisation recognised by the Central Govt., a local authority. State Govt. or the Central Govt. can make an application for compensation.

The Tribunal may take up the cases suo motu. The claimant can ask relief under the Public Liability Insurance Act, 1991.

Fees to be paid with the application is Rs. 1000 and time limit 5 years.

Powers (S.5 to 7) :

Procedure and powers of the Tribunal are mentioned in S.5 to 7 and in Chapter-4 (S. 19 to 24). The Tribunal can make interim orders and deduct the amount of relief or compensation paid in any other law from the compensation to be paid under this Act. Amount payable for damage to environment shall be credited to the Environmental Relief Fund under the Public Liability Insurance Act. The order of the Tribunal shall be executable as a decree of civil court. The amount shall be recoverable from the owner as arrears of land revenue or of public demand.

Appeal shall lie to the Supreme Court and shall be preferred within 90 days.

Establishment of Tribunal (S.8 to 18) :

The Central Govt. shall by notification, establish it. It shall have Chairperson, Vice Chairpersons, Judicial Members and Technical Members. A Bench shall consist of one judicial and one technical member. Their qualifications are prescribed in S. 10. Age of retirement for Member, Vice-Chairperson and Chairperson are 62, 65 and 70 respectively. Provisions are made for their salaries, allowances, powers and staff etc.

Penalty : Imprisonment upto 3 years or fine upto Rs. 10 lakh or both, for not complying an order by the Tribunal.

Section 31 gives rule making powers to the Central Government.

E X E R C I S E

1. Explain, State, Mention or Discuss :

1. History of doctrine of social security.
2. When Employer is liable to pay workmen's compensation and when he is not ?
3. Main provision of the Employers Liability Act 1938.
4. Six types of benefits available to an employee under the ESI Act.
5. Which benefits an insured person cannot get for the same period under the ESI Act?
6. Objects of Public Liability Insurance Act 1991.
7. The schedule of relief under the PLI Act.
8. The relief procedure under the PLI Act.
9. Role of District Collector under the PLI Rules 1991.
10. Statutory provisions under which any person other than a workman can claim compensation.

2. Write Short Notes on :

1. Social accountability.
2. Refusal of worker to undergo medical examination.
3. Deposit of Compensation OR Medical examination under W.C. Rules.
4. Method of calculating amount of compensation in case of death and disabilities.
5. ESI Act - its advantages and misuse.
6. Benefits for workers and their families under the ESI Act & Rules.

7. Time limit and penalty for late payment of contributions under ESI Regulations 1950.
8. Types of contributions under ESI Act.
9. Current rates of contributions under ESI Rules.
10. Sickness benefit OR Disablement benefit.
11. Dependants' benefit OR Maternity benefit.
12. Criticism, regarding ESI scheme.
13. Physically handicapped person and statutory provisions for him.
14. Gujarat Act for Unemployment Allowance to workmen.
15. Liability of Owner under the Public Liability Insurance Act 1991.
16. Statement of Objects and Reasons put before passing of National Environment Tribunal Act 1995.
17. Preamble of the National Environment Tribunal Act 1995.
18. Powers of Tribunal under the National Environment Tribunal Act 1995. 19. Purposes of the ESI fund.
20. Social security for unorganised workers.

3. Explain the Difference between :

1. Partial disablement and Total disablement.
2. Temporary disablement and Permanent disablement.
3. Contribution and Compensation.
4. Different types of Dependents.
5. 'Workman' under the WC Act and 'Employee' under the ESI Act.
6. Contributions and Benefits.
7. Disablement benefit and Medical benefit.
8. Sickness benefit and Disablement Benefit.
9. Provisions of the WC Act and those under the ESI Act.
10. 'During employment' and In course of employment'.
11. Benefits under the ESI Act and those under the WC Act.
12. Coverage of WC Act and that of ESI Act.

4. Comment on following explaining whether it is True or False?

1. In case of death of a worker, compensation can be paid to him directly i.e. out of court also.
2. Compensation payable to woman or minor should be paid through court only.
3. Six months' wages are payable in advance and subsequently deductible as compensation.
4. Accident compensation claim should be made within 1 year under W. C. Act.
5. Reports of fatal accident or serious bodily injury should be given within I month under the W. C. Act.
6. Workman's compensation is not a charge on Employer's assets.
7. A workman has right to relinquish his right of compensation under the W.C. Act.
8. Disablement benefit can be commuted for a lump sum amount.
9. If an employee is entitled to get more than one benefit, he is eligible to get them.
10. If contribution is not paid, benefit cannot be available.
11. Unpaid cash benefit cannot be given to nominee of a deceased employee.
12. For any misconduct an employee can be dismissed from service even during his period of sickness.
13. Public liability insurance amount cannot be more than the paid-up capital of the company.
14. If accident due to 'hazardous substance' is not possible, public liability insurance is not necessary.
15. Medical expenses up to Rs. 25000 and Rs. 12500 more in case of fatal accident are available as relief under the PLI Act.

16. Wage loss compensation for disability is 'available @ Rs. 2000 p.m. under the PLI Act.
17. Fine up to Rs. 10 lakh is possible for not complying an order by the Environmental Tribunal.
18. Public liability is for social security

Reference and Recommended Reading

1. Encyclopaedia of Occupational Health and Safety, ILO, Geneva.
2. Industrial Law, by 'P.L.Malil<, Eastern Book Co., Lucknow.
3. Statute Books of the respective Acts & Rules.
4. Health Insurance in developing Countries:- The Social Security Approach by A. Ron, B. Abel-Smith and G.Tamburi, By ILO

Note : The content mentioned in this chapter must be updated with the Amended Law for the • purpose of Examination or Application.

CHAPTER – 30

Accident Case Studies

THEME

1 NEED OF ACCIDENT CASE STUDIES

We do not wish any accident, but when any accident takes place, it teaches the real lesson. Our knowledge and safety measures are tested and we are compelled to acquire the knowledge of the causes of that accident and of preventive measures to stop its recurrence. This requires thorough investigation and correct conclusion. That shows us the path of safety. Thus any accident has two effects; bad and good. The loss or injury is the bad effect and the knowledge acquired to prevent similar occurrence is the good effect. Thus we have to utilise the accident causes to raise our knowledge for the purpose of safety and this becomes possible by the case studies. A case study sharpens and tests our knowledge and arrangement and asks us why did they fail? We rethink our arrangement and management (which failed) and turn to redesign it on the bases of that real case study. That is the utility of any safety case study whether it may be an accident case or a non-accident experiment. However an accident case study gives much experience. Some typical and real cases are narrated below in brief.

2 THE WORLD SCENARIO

In the history of industrial disasters, Bhopal Gas Disaster of 1984, remains at the top because of more than 2500 fatalities and thousands of injuries and aftereffects. Before Bhopal, the world had seen many chemical disasters, but the public attention was not drawn that much.

On 21-9-1921, at Oppau, Germany, warehouse explosion took place due to dynamite being used to pry loose cracked ammonium nitrate. The deaths reported were 561 and damage upto 30 km distance.

In 1942, at Honkeiko, China, 1572 died due to coal dust explosion.

In 1944, at Cleveland, USA, LNG(Methane) storage tank exploded due to structural weakness resulting in 136 deaths and 77 injuries. In the same country on 15-4-1947 at Texas, explosion took place in a ship carrying ammonium nitrate bursting nearby styrene plant resulting in 576 deaths and some 3000 injuries.

On 29-7-1943 at Ludwigshafen, W. Germany, in BASF company, explosion took place in a road tanker containing 16 T butadiene and butylene and 57 died, 439 injured and nearby buildings collapsed. In the same company, on 28-7-1948, again explosion (overfilling and expansion due to sun heat) took place in a rail tanker containing 30 T dimethyl ether and 207 died and 3818 injured.

In 1950 at Poza Rica, Mexico, 10 died due to phosgene exposure. In 1952 at Wilsom, Germany, 7 died due to chlorine release. In 1973, at Staten Island, USA, 40 died due to LNG fire.

In 1956 at Cali, Columbia, 1100 people died in a dynamite truck explosion.

Famous Flixborough (UK) explosion occurred on 1-6-1974. In a caprolactum plant, a temporary bypass pipe was broken and vapour came out. It resulted into fire and explosion. The plant was ruined into pieces, 1821 buildings and 167 shops broken down, 28 died and 89 were injured. As a consequence, in 1985, ' CIMAH Regulations were passed in European countries.

In 1975, coalmine explosion took place at Chasnala, India, causing death of 431 people. In the same year propylene explosion took place at Beek, Netherlands causing 14 deaths and 107 injuries.

During 1976 to 1979, the Love Canel near Niagara Falls, USA, reports were published regarding effects of buried waste at this Canal. A number of birth defects and miscarriages were reported. amongst residents in the vicinity of the Love Canal. A law-suit was filed in 1979 against the Hooker Chemical Co. for its earlier use of this Canal. This drew attention of many such toxic waste sites in the USA and led to the legal exercise of 'waste minimisation approach', the 'waste audit' and the law relating to it.

Famous Seveso (Italy) accident occurred on 107-1976. In a chemical factory, a safety valve opened and some 2 kg TCDD(Tetra chloro dibenzo pera dioxene) vapour released into the atmosphere and 250 people were to be evacuated and a large area was polluted. As a consequence, safety instructions known as 'Seveso Directives' were issued. These directives required disclosure of information and drawing up of emergency plans to reduce the frequency of disasters and consequential damage.

In 1977 at Cartagena, Columbia, 30 died and 25 injured due to ammonia emission.

In July 1978 at San Carlos (Spain) propylene gas tanker (24 T) dashed into a wall and exploded. 215 people died. In the same year, at Chicago, Illinois, USA, 8 died and 29 injured due to HS exposure.

In 1979 at Novosibrisk, USSR, an accident took place in a chemical warfare plant killing some 300 people. In the same year accident took place because of water ingress in a reactor in a nuclear power plant at Three Mile Island, USA.

The year 1984 noted 3 disasters including Bhopal gas (methyl isocyanate) leak on 3-12-1984, killing some 2500 people and injuring over 20000. At Cuhato (Brazil) fire and explosion took place from a leaking Gasoline pipeline resulting into deaths over 500. At San Junico (Mexico), explosion took place at the Pemex Co., LNG storage depot on 19-11-1984, causing deaths of 542 people and injuries to more than 4000.

In 1985, LPG BLEVE occurred at Mexico city, causing 650 deaths and 2500 injuries. On 11-8-1985, at West Verginia Institute, USA, methylene chloride and aldicarb oxime mixture came out from a safety valve due to runaway reaction. 134 people were hospitalised.

On 26-4-1986, from Chernobyl Nuclear plant, USSR, atomic radiation came out killing 31 and causing radiation sickness to 203. The serious point was of the evacuation of more than 135000 people and 280 cancer deaths were predicted during next 70 years.

Every year disaster takes place at some or the other place. Therefore such list becomes long. Let us see some reported cases during last few years.

In 1993, (1) at Bangkok, Thailand, 250 killed in fire in a doll factory (2) 9 killed and 53 affected by acid fumes from a chemical plant at Shahad, Maharashtra and (3) 61 killed and 21 injured in a blast in a chemical plant at Beijing, China.

In 1994 (1) 55 miners died in a colliery at Asanol, West Bengal (2) 70 'miners died in a mine due to gas explosion by a short circuit at Beijing, China (3) 18 killed in a blast in cement factory at Hyderabad, AP (4) 26 died and 76 injured by fire crackers at a religious festival at Chikal-thana, Maharashtra (5) 34 died in explosion in a fireworks factory at Jhansi, MP (6) 132 killed in a fire in oil refinery at Cairo, Egypt and (7) 233 died and 16 injured in a fire in a dance hall at Beijing, China.

In 1995 (1) 109 died and 160 injured due to a leaking gas pipeline explosion on road at Taegu, South Korea (2) 4 killed due to methane leak from BPCL pipeline in Chembur, Bombay (3) 4 killed and 2 injured when an empty petrol tanker was being welded at Chhapra, Bihar (4) 23 killed and 9 injured in explosion in a fire cracker factory at Rohtak, Haryana (5) 40 died and 26 injured in a coal mine at Henan, China (6) 2400 T Di-methyl terephthalate (DMT) worth over Rs. 20 crore was destroyed in fire and explosion in a petrochemical plant near Pardi Naka, Nagpur (7) 375 killed by fire in a moving train (underground) at Azeri, Baku, USSR and (8) 368 died when fire broke out due to short circuit at Sirsa, Haryana.

In 1996 (1) 40 died and 57 injured by a petroleum pipe explosion at Henan, Beijing, China and (2) 26 died and some 1000 injured due to massive toxic gas leak from a tanker at Lahore, Pakistan.

In 1997 (1) 343 Haj Pilgrims killed in a fire, possibly due to a gas cylinder burst in a tent at Mecca, Saudi Arabia (2) 60 killed and over 100 injured due to asphyxiation in cinema hall by fire due to short circuit at New Delhi and (3) 60 killed in a fire and explosion in HPCL refinery at Vishakhapatnam, AP.

In 1998 (1) Over 60 died due to fire and explosion in a collision between an oil tanker and 4 other vehicles at Islamabad, Pakistan (2) 500 were burnt by petrol spilled from a burst pipeline in Nigeria, Egypt and (3) II died and 100 injured when a leaking LPG tanker exploded in Guwahati, Assam..

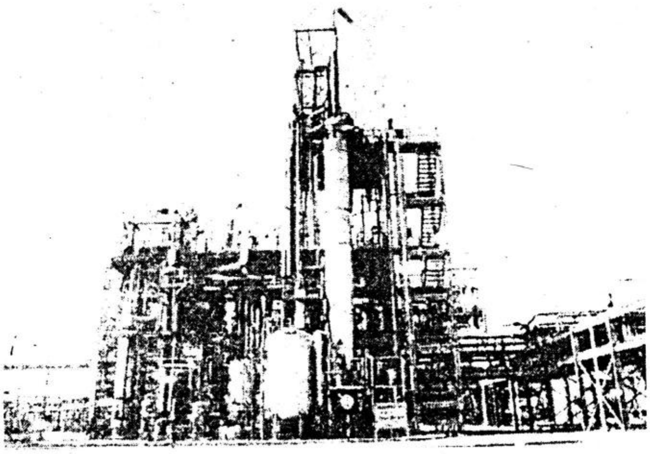
On 7-9-2006, 54 died in a coal mine in Zarkhand due to carbon monoxide after explosion.

The lessons of such world-wide ever happening disasters must be learnt very seriously and it must be determined to work hard to prevent similar recurrences. These disasters are worth studying for safety professionals and government officials to plan for disaster management.

Now some fatal accidents are narrated below in brief to explain their causes and remedial measures.

3 SOME FATAL ACCIDENTS

3.1 Bhopal Gas Disaster :



Union Carbide Plant at Bhopal

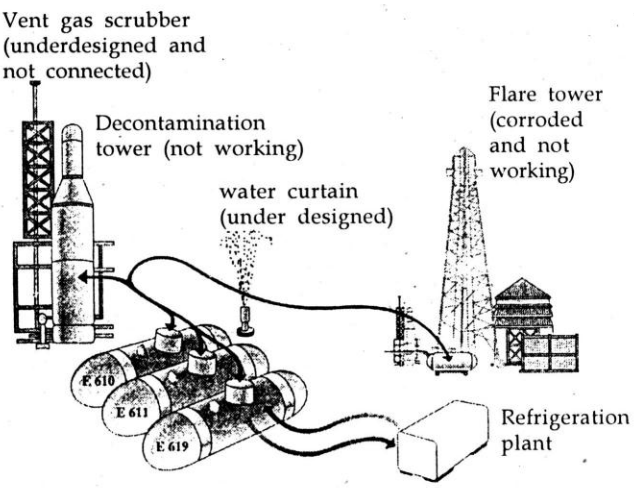
The Facts of the Accident in brief :

It was the night of 2nd December 1984 when the night shift staff of the Union Carbide Factory, Bhopal, took a round at @ II pm. There were three double walled, partly buried S.S. tanks (No. 610, 611 and 619) each of 60 tonne capacity and all containing the poisonous gas MIC (Methyl isocyanate) to be used to produce a deadly pesticide Carbaryl. At @ 11-30 pm. workers in the plant realised that there was a MIC leak some where : their eyes began to tear. A few of them went to the MIC structure and noticed a drip of liquid with yellowish-white gas, about 50 feet of the ground. They told .the supervisor who, however, decided to deal with the leak after the tea-break which ended at 1240 night. Meanwhile the events had moved very fast.

The temperature of the tank 610 had reached 25°C the top of its scale and the pressure was increased twenty times rushing towards 40 psi at which the emergency safety valve was to open. Soon the pressure gauge showed 55 psi, the top of the scale and the safety valve had opened releasing MIC With a loud hissing sound and the tremendous heat. A white cloud drifting over. the plant was. moving towards the sleeping neighbourhood.

The workers tried to operate the safety devices, but nothing seemed to work. The water jet failed to reach the top of the 120 feet stack from which MIC was escaping. The vent gas scrubber to neutralise the escaping gas did not work. The scrubber was under maintenance,, the flow meter was not indicating the circulation of caustic soda whose concentration was also not known since October. The flare tower to burn off the gas could not be 'used because its piping was corroded and not replaced. The refrigeration system, of 30 tonne capacity, to keep the MIC in liquid state at 0°C was closed down since June 1984 as an economy drive and the gas was at 15°-20°C Which was unsafe. For approximately two hours, the safety valve remained opened releasing over 50000 pounds of MIC (might also containing Phosgene, Chloroform, Hydrogen cyanide. Carbon dioxide etc.) out of 90000 pounds stored in the tank No. 610 at the time of the incident. Sometime between 1-30 to 2-30 am. the safety valve reseated as the tank pressure went below 40 psi.

The Causes of the Accident :



Condition of Union Carbied factory at the time of accident.

(A) Unsafe Conditions

From the published press reports they seem to be:

1. The refrigeration system to keep the gas cool was closed since long.
2. The vent gas scrubber was underdesigned, not repaired and not connected.
3. The corroded flare tower pipe not replaced and not connected.
4. The water curtain jests were underdesigned to reach the maximum height.
5. All the three tanks were filled in while one ought to have kept empty to use as emergency bypass.
6. The computerised pressure/temperature sensing system, a warning device to give alarm and to control the situation at the time of abnormal condition was not installed.
7. The carbon steel valves were used instead of stainless steel and the valves 'were notorious for leaking.
8. The instruments to check the valve-leakage were not available.
9. The wind direction and velocity indicator was not installed to warn the people about leakage direction and severity.
10. The neighbouring community was not told of the significance of the danger alarm and the dangers posed by the materials used in the plant.
11. Control instruments at the plant were faulty.
12. Maintenance and operational practices were deteriorated.
13. Chemical reactors, piping and valves were not purged, washed and aired before maintenance operations.
14. The blind disc to disallow the water in the tank through the valve was missing.
15. Under qualified workers were running the factory.
16. People with chemical engineering background were replaced by less skilled operators.
17. The workers' strength was reduced from 850 to 642 during preceding two years and the operators duty relieving system was suspended.
18. The operating manual was grossly inadequate, not specifying all necessary emergency procedures to control abnormal conditions.
19. At the time of accident, in the MIC control room, there was only one operator who found it virtually impossible to check the 70-odd panels, indicators and controllers.
20. A design modification of jumper line to interconnect relief valve vent header and the process vent header was defective, as it allowed the water to go into the MIC tank.

(B) Unsafe Actions:

1. The leak was not attended as soon as it was reported. Initial time passed in tea break.
2. The first information of five-fold pressure rise was dismissed in the belief that the pressure gauge could be faulty.
3. A newly recruited supervisor had asked a novice operator to clean a pipe and the blind disc was not inserted while doing so.
4. The public siren was put on around 1 am. nearly an hour after the gas leakage and that too for a few minutes.
5. The correct antidotes and medical treatments were not suggested to surrounding doctors. On the contrary confusion of MIC or Phosgene or Hydrogen cyanide was confounded.

(C) Unsafe Reactions:

Above unsafe conditions and actions lead to the violent unsafe reaction. Different hypothesis have been expounded by Carbide's scientists, Indian experts and Dr. S. Varadrajan, who lead the investigations on behalf of the Government. According to him small quantity of water reacted with Phosgene in the tank, mixed with MIC as animpurity to make it unstable. The Phosgene water reaction (hydrolysis) produced heat, CO_2, and HCI. The heat and HCI acted as the accelerators of the polymerisation, additions and degradation of MIC leading to a runaway reaction. According to others, the increased temperature of MIC (it vaporises above 38°C) generated heat, pressure and side-reactions, higher than normal amount of Chloroform in the stored MIC and an iron catalyst lead to the violet reaction. Because of the colder night of December, the escaped MIC settled down and travelled downward covering the sleeping surroundings with the blanket of death and damages.

Remedial Measures :

All the 25 major causes of this accident stated above in (A) and (B) suggest the remedial measures. To avoid repetition, all these contributing causes should be removed first and necessary steps should be taken to run the plant always safe and sound, with all the safety devices properly working. The working conditions must be improved and unsafe actions must be removed by proper policy, training and education.

Lessons of Bhopal are well described in the foreword to the IOCU (International Organisation of Consumers Union) in the following words :

".. the deadly cloud that wrought havoc at Bhopal... will continue to rear its ugly head in many forms, in many sizes and in many places. Obviously there are many lessons to be learnt about occupational health and safety, about proper sitting of production facilities, about science and technology, about access to information, about trade secrecy, about 'cover ups', about 'double standards', about medical and legal remedies, about the responsibilities of transnational corporations, governments and international agencies and most crucial of all about what ordinary people can and must do to protect themselves from the plague of such deadly clouds."

Bhopal incident opened the eyes and gave many lessons for the multinationals, for developed countries and for the developing countries.

Human life must be equally valued everywhere. No double standard for developed and developing countries. 'Right to know' and 'Obligation to tell' concepts are to be covered by legislation. Training to staff, and workers, emergency procedures, highest standards for plant operation and maintenance and safety equipment, 'worst case' study and assessment, etc. were incorporated in 1987 by the amendment of our Factories Act, 1948.

Site for Bhopal tragedy case study http://www.cdc.gov/elcosh/docs/other/com software, html

3.2 Flixborough Explosion :

At @4:53 p.m. on June 1, 1974, a huge Cyclohexane vapour cloud of about 200 m diameter and around 100 m high, rose from the Nypro Chemical plant in Flixborough, England. The base of cloud extended into the furnace area of the adjacent Hydrogen plant where it probably ignited suddenly. There was a devastating explosion of the vapours, heard 27 miles away, 28 persons were killed and over 36 injured. The 72 million dollar Nypro plant was totally destructed and varying degrees of damage to 2,488 surrounding homes, shops and factories within an eight mile radius also resulted.

The cause of the disaster was found by the Court of Inquiry to be the failure of the 20 inch bypass pipe. The failure, as per Mr. D.M. Tucker of the Fire Research Station, was a very noisy event, specially the release of the Cyclohexane from the stub pipes and the rumbling of Cyclohexane boiling in the reactors. The vapour cloud that formed exploded after 45 seconds of the leak. The Court ultimately theorised that the 20inch assembly failed in one step because of weak points in its own design. Hence, the Court of Inquiry felt that the omissions in design consideration of the temporary modification destroyed the integrity of a well designed and constructed plant. The Court of Inquiry concluded that "There was no Mechanical Engineer on the site of sufficient qualification, status, or authority to deal with complex or novel engineering problems and insist on necessary measures being taken". Nypro management recognised this lack and had arranged for consulting service on any modification that was identified as decidedly hazardous.

The primary cause of Flixborough disaster was an attempt to bypass reactor No. 5. The manner of bypassing revealed serious shortcomings in management procedures. The plant integrity was destroyed. Other weaknesses were : no detailed drawing, no stress analysis of the bypass line, not following BS 3351, the bellows and bypass assembly were not pressure tested before it was fitted and the testing of the bypass at a pressure lower than the safety valve release pressure (II bar) which were the sheer foolishness.

The three main lessons of Flixborough disaster are:

1. Management system deficiencies i.e. no skilled and qualified engineer, no standard modification procedure, no clearly defined role of safety officer etc.
2. Need to notify hazards on site to the local authorities and their guidance to the industry and
3. Restriction (licensing) on storage of hazardous chemicals on site.

This disaster led directly to the CIMAH regulations in the UK.

3.3 Toxic Release At Seveso :

In the lcmesa Chemical Co., at Seveso in North Italy, on 10-07-1976 at.-~-30 am, a reactor safety valve vented to the atmosphere, 2,3,7,8 -Tetra Chloro Dibenzo para Dioxiir(TCDD) a toxic gas. It's cloud drifted over the adjacent town and came down to earth because of heavy rain. The management tried to inform the local community but they had a communication problem. Key people in the local authority could not (be reached due to weekend and they were on holiday. When they were finally alerted and began to take action, they didn't know what to do. Some 250 people were to be evacuated. Visible casualty were not numerous but the toxic contamination of the area was not cleared even after the expenditure of some US$ 200 million.

This Seveso accident proved a landmark for the chemical industries world-wide. Then after, the release of toxic chemicals into the river Rhine from Sandoz warehouse at Berne in Switzerland was demonstrated dramatically. This issue was taken up by the ECC and after protracted deliberation, the so-called Seveso Directive(Control Of Industrial Major Accident Hazards Regulation) was issued in 1984 and duly ratified by the member governments.

The extreme toxicity of TCDD and other Dioxins was known before Seveso but didn't received publicity till then.

This accident makes it clear that the manufacturers should not be reluctant to publicise what they are doing and assess their process very carefully to ensure that there are no similar hidden hazards.

The Seveso directive was implemented in phases from 8-1-1984. The directive calls for relevant information and preparing of emergency plans to cope with 'if ' situation. Such emergency plans can help to reduce the chances of disasters and their consequential damage.

3.4 Chemobyl Nuclear Disaster :

After Bhopal disaster, the next remarkable disaster took place at Chemobyl Nuclear Power Station in the Soviet Union on 26-4-1986 and the losses reported are as under.

The accident led to 31 deaths and 203 have suffered various degrees of radiation sickness. 14 were in hospital with 80 to 90 per cent burns due to radiation. The 1,35,0100 people around Chemobyl who were evacuated to safer sites would be monitored for radiation effects. Among this group there will probably be 280 more cancer deaths than normal over the next 70 years. The Soviet scientists analysed a total population of 74.5 millions in II different regions, the most heavily populated being the urban areas of southern and eastern Ukraine for long-term impact of the radiation release. About 5,000 fatal cancer cases are likely from the release. This must be looked at in comparison with some 9,500,000 cancer cases anticipated from all other causes over the 50- year period in the same population. And an additional 1,500 deaths are predicted from thyroid cancer in people consuming contaminated milk and other foodstuffs.

The Causes of the Accident :

A detailed report is published in Front-line of October 4-17, 1986 of which a short abstract describes the causes as under.

The operating personnel at Unit 4 of the Chernobyl nuclear power station in north-western Ukraine 'had virtually invited the disaster. In a series of unauthorised and impermissible actions, the plant personnel, while trying to perform a rather banal experiment, tinkered dangerously with the reactor, triggering the calamity. The accident spread radioactivity and panic all over Europe and revived the worst fears about nuclear energy.

The Chernobyl reactor was an advanced system with a number of computerised monitoring and control mechanisms. These provided for the regular monitoring of the various parameters of the reactor, including temperature, pressure and water flow rate. There were batteries and diesel generators for back up power in case the main source failed. A system of light and sound alarms in the control room would alert the plant operators to danger. Plant conditions were printed out automatically. There were a variety of mechanisms, including an emergency core cooling system, to bring the reactor under control in case it showed signs of instability. .

The cause of the tragedy was not the absence of safety systems. The accident was due to the fact that most of these protective systems were turned off by the plant operators as they conducted a fatal experiment on April 25-26,1986.

The unit had an electrical capacity of 1000 MW and a thermal power rating of 3200 MW. The experiment was to be conducted at 25% power. Therefore the turbo generator No. 7 and the emergency core cooling system (ECCS) were switched off. The aim was to prevent a spurious triggering of the ECCS during the turbine test but it eliminated one key safety device. However the test was postponed till late in the night and the power reduction was resumed at 11 am. on April 25, in preparation for the test.

But the operators found it difficult to maintain the reactor at 700-1000 MW thermal power, the optimum level for the proposed experiment, because of the error in switching off the local automatic control of the reactor, the power level fell to I percent. By I am. on April 26 they managed to stabilise it at around 6 percent (200 MW thermal). At the same time they

After sustained operation of a reactor, xenon gas builds up, absorbing neutrons needed in the chain reaction and slowing down the rate of fission.

To counteract the xenon poisoning, the operators pulled out control rods from the core, leaving only six to eight in place instead of the stipulated minimum of 30. This perhaps was the major blunder which set the stage for the reactor running out of control.

The operators then began to introduce further disturbances in the reactor. They engaged all the eight pumps instead of the normal six, with two as reserve, to cool the reactor. This dramatically increased the water flow in the reactor. More water meant less steam and the water-steam balance in the reactor core was upset and steam pressure in the drums where steam is collected began to fall. This would have in the normal course led to .an automatic shut-down of the reactor, but the staff blocked the emergency protection signals from the steam drums. Thus one more safety device was put out in an effort to press on with the tests.

By 1:22:30 am. on April 26, the state of the reactor called for a shut-down and cancellation of the experiment. But the test began. At 1:28:04 turbo generator No. 8 was cut off from the steam. A minute earlier the operator had abruptly reduced the flow of make-up water, thus increasing the water temperature in the reactor. The switching off of both the turbo generators would have triggered an automatic shutdown but the operators blocked the reactor protection system, relying on shut-down signal from two turbo generators. This error was committed with the intention of repeating the experiment a second time.

Meanwhile as the turbine ran down, the water flow in the reactor began to fall sharply since four of the eight cooling pumps were running only on the residual energy of the turbine. Because of the water steam imbalance and the positive void coefficient the power of the reactor began to surge rapidly. Within 56 seconds, the shift manager realised that something had terribly gone wrong, and at 1:23:40 am. called for a complete shut-down of the reactor, and pressed the scram button to let the control rods down into the core, but unfortunately the rods did not reach the bottom, and an operator cut their controls hoping they would fall further on their own. But instead they got stuck, probably due to the thermal distortion already set in 'at the core as a result of the high temperature. The effort to shut down the reactor was too late. Within three seconds, power output surged from 200 MW (thermal) to more than 530 MW (thermal). By l;24 there was a huge explosion, followed by a second one., The Soviet investigators theorised that the initial blast that blew the reactor structure could have been caused by the steam explosion. As the power output surged there was intense steam formation around the fuel which in turn reduced the ability to remove heat from the fuel elements and the resulting explosion wrecked the building.

The second explosion could have due to the formation of Hydrogen. The steam in the reactor would have reacted with the zirconium enclosing the fuel elements and the graphite moderator of the reactor, generating large quantities of Hydrogen, which exploded when it mixed with air. The two explosions sent hot radioactive fragments high into the atmosphere. The debris from the explosions eventually set off about 30 fires in the plant.

Thus the issue posed by Chernobyl is the fallibility of modern technology. The disaster at Chernobyl and that of the US Challenger raise a number of questions about man-machine interface, the complexity in the management of modern technological systems,, the pressures of their routine operation, the strains on large bureaucratic organisations involved in running advanced technological systems, the external economic and political pressures on them and the like.

Preventive Measures:

The preventive measures seem to be (1) The written and approved procedure to carry out any new experiment (2) No isolation or bypassing of safety devices .(3) Presence of the most experienced senior officers in the plant instead of leaving it in the hands of operators (4) HAZOP and Consequence Analysis of new experiment on such radiation system and (5) Following safe close down procedure in case of any abnormality.

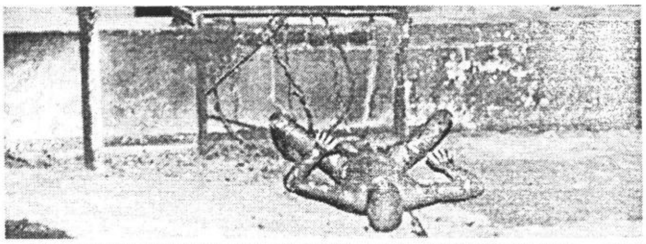
3.5 Toluene Distillation :

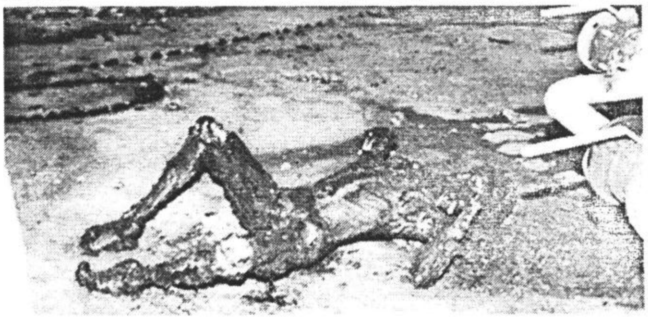
In a factory manufacturing Oxyphin butazone, the process of toluene distillation was going on. While removing choking in the bottom drain pipe, due to hammering, the pipe was broken and the toluene came out which was immediately ignited due to spark from a nearby boiler. The distillation column was also choked (this was found on internal examination) and it has created resistance and back pressure in the vessel. The steam (heating media) pressure was also suddenly increased which in turn increased the vessel pressure. All such causes led to an accident in a small factory causing deaths of 10 workers due to burn' injuries.

Safe procedure for dechoking, automatic pressure-temperature control with alarm and heat source cut off device, no source of ignition (boiler) nearby, regular cleaning of distillation assembly were all necessary.

3.6 Fire of Ethylene Oxide :

A truck-tanker of Ethylene oxide, a highly flammable liquefied and pressurised gas, was to be unloaded from the truck body. While reversing the truck by a helper (driver was not available), the main valve of the tank was struck and broken releasing the EO with high pressure. The truck engine was running and the exhaust gas was sufficiently hot and generating some spark just near the released gas, the EO ignited all of a sudden and the fire was uncontrollable. The whole factory with the truck burnt into ashes and a few workers died due to severe burn injuries.





Instead of EO tank unloading, use of a fixed EO tank and fixed pipe line transfer, spark arrester on truck exhaust, safety work permit, fixed and safe unloading bay and precaution while driving were all essential. Trained driver should drive the vehicle and not a helper.

3.7 Phosphine Exposure :

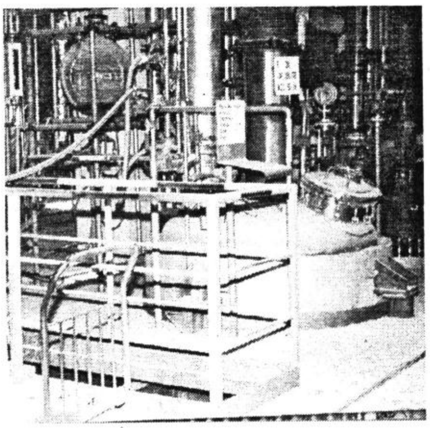
In a factory manufacturing Aluminium phosphide (pesticide), while emptying the AIP pot, a worker inhaled the phosphine gas (PH) which proved fatal. The concentration was many times more than the TLV prescribed and the worker had not worn any respirator or protective equipment. This gas is highly toxic and affects the CNS also. As it is not visible and has no smell, its regular monitoring and control are most necessary. It has fire hazard also. Local exhaust ventilation, use of personal protection and dry atmosphere are desirable.

3.8 2-4 and 2-5 Dichlorophenol :

2-4 dichlorophenol is a highly toxic chemical which caused a death within 15 minutes. Reported cases of this chemical were also indicating all deaths within 15 to 20 minutes. A worker Was filling a carboy with a rubber hose pipe of 1.5 inch outer diameter. The filling pump-motor was pushing the liquid and the house pipe end was tightly inserted into the mouth of the carboy without any air vent. The pipe was subjected to the internal pressure and as it was breakable, it was punctured all of a sudden. The worker standing nearby was sprayed by the chemical. He had not worn the PVC protective suit given to him. He took immediate water wash but could not survive while shifting to the factory dispensary. The strong metallic pipe, proper venting, use of PPE and automatic filling (avoiding manual transfer of a toxic chemical) were necessary.

In another case, a worker died due to splashes of 2-5 dichlorophenol. The chemical came out from a drain valve. The worker took bath for 10 minutes but he died within half an hour. PPE could have saved him. Drain valve in locked closed condition was the basic requirement.

3.9 Exothermic Reaction :

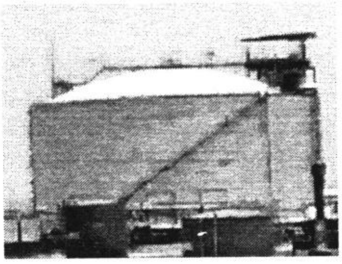


In two factories during exothermic reaction going out of control "(runaway reaction) the reactors were burst with tremendous pressure causing heavy damage to the structure of the factories and surrounding areas. In the jacket the cooling media (water) was interrupted and no alternate arrangement was available to circulate the cold water. The heat of reaction could not be controlled which accelerated the pressure to shear off the top lid and to throw it away with all its attachments.

Constant supply of cooling water and water interruption alarm, safety valve/rupture disc, reaction quenching device, standby pump and alternate power for cooling media, pressure-temperature controls, scrubber connection for toxic outbreak, condenser for organic vapour, training and supervision, automatic heat source cut-off device, drowning tank with by pass line and remote 'controls are necessary.

3.10 Hydrogen Explosion :

In a sulphuric acid plant the Oleum was stored in a big iron tank. Because of the rain water entering inside and due to the reaction of water, oleum and the iron plate of the tank. Hydrogen gas was generated and accumulated in the tank. Therefore while starting a welding work, due to the intense heat vibration or first welding spark, a great explosion took place breaking the tank top and throwing down the workers carrying out welding on it.



Work permit system and testing of H_2 or explosive air mixture with an explosimeter were desirable. Most necessary.

3.11 HCN Gassing :

One worker died and six badly affected by Hydrogen cyanide gassing in one factory. The workers were trying to remove D.P. cell of the measuring tank. At that time HCN mixed liquid came out from the nozzle and sprayed on the worker. Due to the inhalation of HCN vapour which is highly toxic the health hazard arose and resulted as above.

Work permit system, gas testing, personal protection (SBA) and removing it first before starting such work were essential requirements.

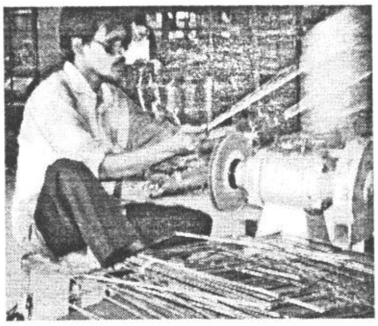
3.12 Acrylonitrile Fumes :

After emptying truck-tanker into a storage tank, some amount of acrylonitrile fumes were remained in the tanker. When the supervisor went away for some work, the truck driver tried to open the flange of the rubber hose pipe. In doing so, acrylonitrile fumes came out and one worker who inhaled much, died subsequently.

Here also work permit system of not allowing unauthorised person or work, personal verification, use of PPE and constant supervision are most necessary.

3.13 Grinding Wheel:

After changing a grinding wheel of 18 inch dia and without fitting the wheel guard, a worker started work on it. Due to over/under tightening or material defect, the revolving wheel burst and due to the severe injury by its thrown away pieces, the worker died.



The wheel guard, proper fitting and testing are the basic requirements..

3.14 Ball Digester Blunder :

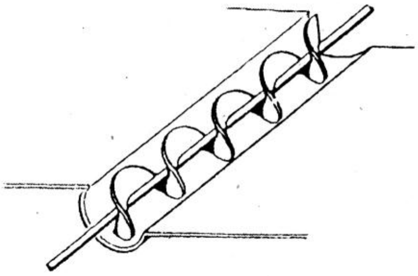
In a paper mill two workers died due to a blunder of third worker who operated the wrong switch. The big digester was filled with hot water, steam, pulp and caustic and at a pressure of @ 70 psi. It was to be discharged and therefore fitted firmly with the discharge pipe. During night, two workers were slipping near the digester. Another worker intending to start the flow pump motor, by mistake, started the digester moving motor. Due to the 10 HP force, torque, bending moment, shearing stress, hoop stress and temperature stress of the inside steam, the discharge joint sheared off from the connection. Some 20 tonnes steam and hot liquid rushed out and covered the sleeping workers who died on the spot. The electric switch should be locked in such cases.

In the same paper mill in another accident, a worker fell in to the pulper tank and cut to pieces by the revolving blades. Top fencing with interlocked feed opening and conveyer feeding were necessary.

3.15 Pug-mill Gearing :

In a pottery a worker was dragged by the unfenced gears driving the worm gearing of the pugmill. A worker working nearby, caught into the open gears and died due to crush injury. A fixed guarding or fencing on all such gearing or belting is most desirable.

3.16 Screw Conveyer Opening :



In an oil extraction plant a screw conveyer was in use to carry the oilcakes. The conveyer was underground and its feed opening was not closed when it was in motion. While walking on the ground the leg of a worker fell in the feed opening and caught by the screw conveyer. He received crush injury up to his thigh and died in hospital during treatment. Similar fatal accident also happened in a sugar mill, when the wife of a worker (came to call for a lunch) slipped from baggas heap and caught in by a moving baggas conveyer as its feed opening was not properly fenced.

The fixed grill (with small holes), fencing or the hopper is necessary on such feeding point to make them fully safe.

3.17 Unsafe Respirator Connection :

In one factory the catalyst of pyrophoric nature was to be changed and therefore this work was to be carried out in 98% nitrogen (inert) atmosphere. Five workers were doing this job in a reactor at 15" depth. While one worker was coming out, his airline of respirator was detached and started acting like air-gun inside. It was tied inside with other pipes and required quick removal. To take it out, one worker tried to enter inside. His leg slipped from a rope ladder and he fell down. His face mask was displaced and he was exposed to highly oxygen-deficient atmosphere. He was wearing a safety belt but its free end was not kept outside the vessel and in the hands of another worker. Therefore he could not be brought out immediately and died.

Safety measures suggested : No more workers inside, use of SBA with law level alarm instead of air-line respirator, use of safety belt with free end outside and in the hands of another worker, proper vessel entry permit and its strict supervision.

3.18 Fire while Ship breaking :

Many fire incidents have taken place while gas cutting of ship tankers and fatal incidence rate is also very high. In one such incident, 36 workers were working inside an empty oil tank of a ship of 17500 T capacity. Accidentally fire took place while gas cutting. All rubber gas pipes were burnt along with nine workers. Schedule 24 regarding safety from 'Gas cutting/welding' was added to the Gujarat Factories Rules as a consequence.

Safety measures necessary : Complete cleaning of flammable oil waste inside the tank, explosimeter test of inside air-gas mixture, proper lighting, ventilation and safe means of access inside the tank, safe welding torch with non-return valve and its checking before use, fire resistant gas pipes and preferably technique to cut the tank walls by remaining outside the tank and not inside (e.g. fill water inside and cut from outside proceeding from top to bottom).

3.19 Hidden Hazard :

Four workers died when the roof a phthalic anhydride storage tank burst and very hot material (at @ 150°C) came out and fell on their bodies. The tank was connected to the DCS computerised controls and many safety systems(trips, alarms, indicators, print-out and autocontrols) were built in. Owing to a welding mistake core(inner) pipe developed a hole and steam in the jacket started to enter through this hole inside the tank, reacted with phthalic anhydride, formed phthalic acid and choked the vent lines from inside. This allowed pressure built up inside due to slowly and continuously entering steam. Pressure alarms came but it was presumed that it was indicating choking somewhere and therefore for dechoking constant supply of steam was ensured inside the steam jacketed lines. This allowed more steam entry through the punctured corepipe (hidden hazard as it was not visible or detectable without opening and testing the corepipe) creating more and more pressure inside ultimately resulting into the tank roof rupture (roof joint was the weakest part) and escape of the hot material outside.

Safety measures suggested : At the first pressure alarm, a sample should be taken from the drain to ascertain whether phthalic acid has been formed or not and if it has formed, the steam lines should be completely emptied and to find out the cause of water(steam) entry inside the tank and removal of that cause. At certain pressure(below bursting pressure), pressure relief device should open automatic to transfer the pressure. But this may not be possible due to chocking of inner end of such device.

3.20 Mistake of Valve Operation

One reactor was subjected to pressure as well as vacuum process both. During vacuum process, the scrubber line valve was to be kept closed to disallow air entry but it was certainly to be kept open before starting pressure reaction. Because of shift change and operator change, a mistake took place. Next operator forgot to open the scrubber line valve and started the pressure reaction. Methyl mercapton gas was generated and accumulated inside the reactor. When the worker opened a valve for water addition, the gas came out in high concentration. As he was in cubicle(closed chamber), he inhaled more, fell down alone and kept on inhaling the toxic gas for alonger time resulting into his death.

Safety measures suggested : Preference to use a reactor either for pressure or vacuum purpose only to avoid such type of mistake. Interlocking of the reactant charging valve with the scrubber line valve so that unless the scrubber line valve is not open, the reactant charging valve will not open, thus, disallowing the gas generation possibility. Entry of the valve condition mention in the batch-sheet and personal distress alarm to a worker working alone to indicate his immobility.

3.21 Loading-arm Failure :

While filling liquid ammonia in a road tanker at 8 bar pressure through a loading arm, the threaded coupler was opened accidentally, the liquid ammonia rushed out from the detached pipeline as well as from the tanker, the operator standing on the loading platform tried to run away, but fell down, inhaled much ammonia and died on the spot.

The safety measures suggested : The loading arm coupler should be threaded as well as bolted for double safety and the threads should be regularly checked by a thread gauge. Arm joint should be of such a nature that it will stop the flow when open accidentally. The loading valve should be remotely controlled to keep away the worker. Valve should be opened gradually and very slowly. Proper respirator should be worn if exposure is possible. Wind direction should be checked while placing the road- tanker. Stair-cases should be available on both .the sides of the platform for easy run-away.

3.22 Electrical Accidents :

Many fatal accidents have been recorded because of working with portable electric equipment or electrical machines or electric line. Examples are : (1) Fall from height due to electric shock from a handheld portable drill, the insulation of live conductor was broken and that wire touched the metal stool on which the worker was standing (2) Shock due to phase wire opening and touching the metal case of an electric grinder (3) Shock, due to unearthed portable cement concrete mixture and short-circuiting of main switch (4) Touching of an open phase wire while standing on machine(metal) part and replacing a tube light and (5) Opening of insulation of phase wire due to lying on and friction with sharp edge of a vessel and touching the vessel unknowingly. In all five cases the workers died.

To prevent such common accidents it is essential that proper earthing should be ensured before starting the work, ELCB (earth leakage circuit breaker) in power supply line, use of insulated surface like wood, rubber mat, use .of electrical safety hand gloves, hanging loose wires at a height instead allowing them on the ground or resting on metallic parts, checking of broken wires and proper earthing and bonding while transferring flammable liquids.

3.23 Pesticide Poisoning :

Many fatal accidents have occurred in pesticide factories. One worker died due to inhalation of vapour of an organophosphorous compound in an agrochemical formulation factory. In other factory perchloro methyl mercaptan came out and sprayed on a worker's body. He died on the same day. Similar accident took place when because of the detachment of a pump delivery pipe, phosphamidon technical came out and touched a worker's body. Its vapour also entered through his nose and he was died. In one such factory while opening a valve in the effluent treatment plant, one worker died because of exposure to some pesticide liquid and vapour mixed with and arriving there with other effluent

Safety measures to avoid such pesticide poisoning include : Handling and fixing/ packing of pesticide material(liquid or powder) in a closed system working under vacuum and local exhaust ventilation with safe discharge, use of efficient respirator with faceshield, apron, hand gloves/sleeves, long pants and avoiding any kind of direct body contact, immediate cleaning of spillage or leakage with effective neutraliser and burning of such waste material in a safe manner, proper washing, cleaning and disposal of empty containers. Fully automatic filling, sealing, weighing and conveying machine in a closed chamber with local exhaust ventilation is most desirable. Use of conveyer belt to move filled bottles or other containers to avoid manual handling. Training to workers regarding hazards of 'pesticides and safe method of working, use of PPE and safety shower, bathing, washing, etc., constant supervision and cautionary notices, pre employment and periodical medical examination of workers (RBC & blood cholenestarace test) and it's records, keeping PAN, atropine, etc. antidotes in sufficient stock, no drinking/eating in a workroom, washing hands and mouth before and after eating, changing contaminated clothing and informing any exposure or contamination immediately.

See also Sch. 15 and 19, GFR and Part-24 of Chapter-23.

3.24 Falls are mostly Fatal :

Most of the fall accidents result into deaths and therefore fall prevention philosophy should always consider that falls will mostly be fatal.

While replacing AC sheets of roofs many workers have fallen and died. Despite of use of crawling board or cat ladder, safety belt, etc. fall accidents are continued because 'of some error somewhere. Therefore it is high time to legally prohibit the use of a fragile roof on industrial sheds. Till this is not done, the only alternative is to use crawling board or the cat ladder and any fall arrester device including a safety net firmly tied underneath of work. As length of safety belt lifeline is not permitted to be more than 2 m, it is quite inconvenient to move on wide area of the roof and very difficult to find an anchor point to tie the free end of the lifeline within a radius of2m.

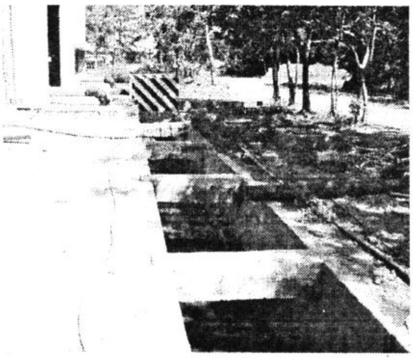
Economy in using a fragile roof should not overturn the value of human lives as far as the concept of safety is concerned. See Chapter-1 for Health v/s Wealth and a number of reported cases of loss of human lives because of unsafe conditions.

Use of corrugated metal sheets, RCC roof or tiles supported on wooden or metal frame of small openings seem to be the safer way. Modern fall arrester devices with support stands and convenient to move horizontal or vertical are also useful.

Compliance of section 32 of the Factories Act and Rule 68E, GFR, while working at height is most important. For further details see Part-5.7 of Chapter 16 and Part-5.6 of Chapter -25.

3.25 Gutter Accidents :

Networks of gutter piping of varying diameters are always laid down in most of the cities, factories, residential colonies and buildings. Many fatal accidents have taken away the lives of young workers engaged in cleaning of such gutters. Seeing an unsafe condition of one such worker while cleaning a septic tank in own house. Dr. Barnadino Ramazzini of Italy, carried out research work on health hazards to workers, published a book in 1780 and was called a father of the branch of occupational health.



Confined space of small chamber or pipe filled with dirty water, sewage, mud, sludge, filth, excretion, sticky surfaces, darkness, insects, bacteria, the worst smell, the poisonous gases like methane, HS, CO, C0,„ N, NH, and oxygen deficiency all at as time, pose the . greatest hazards to the workers who undertake the job of cleaning or dechoking such confined space. No body would prefer such work and mostly contract workers are left to such job in very pitiable condition. Fully mechanical system (e.g. gully sucker) eliminating manual labour is the only best solution.

In Surat city 14 workers died during 2 years, who were engaged for gutter cleaning. II workers died during 6 years of Sewage Disposal Works, Vadodara. Many individual and 2 to 3 workers died while drainage cleaning at many places (Issue-31, June 1996 of Worker, Occupation & Health, Vadodara).

"Bursting of a Septic Tank - a case study" is reported in Oct-Dec 1996 issue of Industrial Safety Chronicle, Mumbai. It described an explosion in a latrine block inside a large jute mill injuring 14 workers of which 7 died. The article is written by two factory inspectors, C.L. Dey and S. Chattopadhyay and provides many details.

The causes of this accident were : Design of the septic tank not as per IS:2470 and inadequate size, no cleaning of the tank since 16 months and overfilling of the working depth of the tank, blockage of gas passage to escape from the tank, methanogenesis and natural degradation reaction generating gas pressure, leakage of gases through cracks and crevices, formation of flammable gas-air mixture (explosive range of methane 5.3 to 15%), workers' habit to smoke inside the latrine and throwing lighted bidi ends here and there, to light up waste jute inside the latrine in winter season, fire due to such sources of ignition, initial vacuum due to burning of flammable gas mixture inside and air entrainment in the tank, creation of explosive gas-air mixture inside the tank and its bursting falling down the weakest wall of the tank happened chronologically. Six workers were killed on the spot under die debris while one died in hospital.

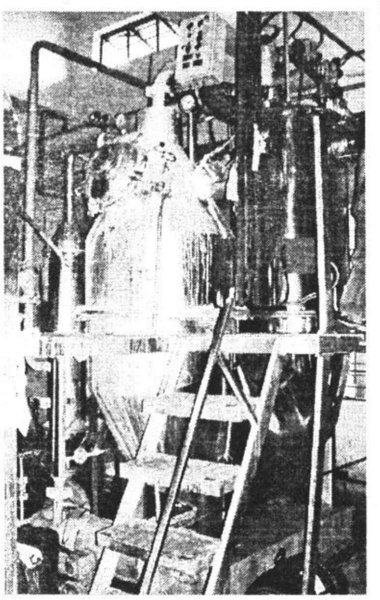
These causes suggest the remedial measures. The sewage tanks should be regularly cleaned before they choked, vent pipes should be kept clean and no source of ignition should be allowed in such area.

For gutter cleaning, first the manhole should be opened and obnoxious smell should be diluted. Other manholes on the same line should be opened to allow ventilation and fresh air. By an air blower internal gases should be sucked out. Flameproof lamp should be used to assess situation. A match stick shall never be ignited for this purpose. Oxygen content should be measured by its meter and a probe. Then level of CO and H2S should be measured by gas detection tubes or other equipment. Lead sodium acetate paper can be used to know the presence of H,S. Methane (CH) is an asphyxiant, colourless, odourless, tasteless gas with bp -161.5' °F, fp -306 °F, vd 0.6, lei 5.3%, uel 15%and it poses fire or explosion hazard when exposed to heat or flame. It is not toxic but it replaces 0 and cause' oxygen deficient atmosphere. The minimum safe oxygen level in air is 18%. Verify this level by 0 meter before signing the gutter entry permit.

Safety belt must be used while allowing a worker to enter the manhole. Its free end should be held by another worker standing outside in readiness to pull him out in case of emergency. If the measured atmosphere is oxygen deficient, the worker should wear self breathing apparatus, proper eye .goggles, hand gloves, boots etc. He should bath and change his contaminated cloths. Medical advice is also required.

3.26 Bursting of Jet -Dyeing Vessels :

In cloth dyeing factories many accidents-fatal and serious- have taken place while working on or near U-type Jet Dyeing Vessel which is a pressure vessel operating at 3 to 4 bar pressure and upto 130°C temperature. Cloth and dye-liquor are fed into it. Dye liquor is heated and cooled in a heatexchanger by steam and water. Vapour of the heated liquor (coloured water) exerts pressure. Sometimes slight air is also injected inside to maintain heating under pressure. The cloth is circulated in dye-liquor for uniform dyeing. Mostly the process is run by auto-controllers as per the programme of heating cooling time, pressure-temperature control etc. 'Safety valve, pressure cut off switch, auto depressure valve, alarm, pressure gauge etc. are provided.



Types of accidents take place include : Bursting. of the vessel killing a worker and damaging the structure, opening of bottom filter drain cover or top manhole cover and burn injury by the hot water.

Safety measures required are : Rupture disc in addition to a safety valve so that when safety valve does not operate (mostly it happens so because of inadequate size and poor maintenance) the rupture disc will release the pressure. High pressure alarm and automatic depressurising. Interlocking of the manhole cover with the manual depressure valve so that unless the pressure is fully discharged by venting, the manhole cover cannot be opened. Pressure and temperature gauge side by side, just on the vessel and in the front so that the worker can see that the inside temperature has become atmospheric and it is safer to open the manhole cover. Better hinges of bottom filter cover and big size internal diaphragm plate on filter cylinder to restrict the sudden outflow of hot water, Periodical pressure and corrosion testing of the vessel and its safety devices. Quality welding joints with radiography test and Training to workers for safe operation and maintenance. Use of soft water without salts/'chlorides and heating/cooling through heat exchanger are necessary to reduce the frequency of failure.

For further details see Part-8.3 of Chapter-21.

3.27 Explosion in Induction Furnace :

Electrical induction furnaces are used in foundries to melt metal at @ 1500 °C. In one such factory, explosion took place in molten metal in refractory crucible within the furnace and the red hot molten metal was thrown out and sprayed on the nearby workers. Six were injured of which three died. Similar accidents took place elsewhere also.

The cause of this accident was breaking of refractory lining from inside, contact of molten metal to the cooling water coil and melting of its wall causing puncture, rushing out water circulating at 60 psi pressure, entry of this water into the red hot metal at 1000 to 1500 "C, immediate steaming and flashing inside the metal resulting into its outbreak. The scenario is very dangerous.

Safety measures include : Regular checking of refractory lining before each heat for any erosion, cracks, damage etc., relining or patchwork with the best quality ramming material to cover the defect, GLD (ground leak detector) system should be provided to detect the thickness reduction or sudden failure in the lining and trip device to cut off power and to stop the cooling water, ultimately to reduce the water content, though it may damage the costly water coil in want of water when red hot metal touches it. But this can reduce the' severity of the accident. Collection pit should be provided just underneath of the furnace to catch and collect the molten material in the refractory brick work. No workers should be allowed to work in the spread zone near the furnace. This can be achieved by proper layout. Workers to tilt the furnace to unload it, should wear fire retardant helmet and clothing.

3.28 Scrapping of Worker :

An asleep worker was dragged by an urea scrapping machine, rapped with urea dust, transferred on a conveyor belt, travelled a long distance, passed through a vibrating screen along with urea and trapped in small passage of a delumper from where his dead body was found after many hours and a long search.

In a fertiliser plant, workers were engaged in urea godown (bulk storage silo) to break urea lumps and to make the surface even. Because of overtime work during night hours, a worker fell into sleep while taking rest near the wall. Urea scrapping machine was working at that time. An operator was driving this machine by sitting in its cabin at a distance However he unnoticed the sleeping worker just in front of him though at a distance. The sleeping worker unnoticed the noise of the machine slowly approaching towards him. At a moment, the revolving jaws picked up 'the asleep worker, dragged and turned him down the scrapping and moving blades, pulled a long distance and shifted him onto a conveyor belt conveying the urea in urea transfer house.

An experiment was carried out by creating the same situation to assess how it happened. A statue was created from cotton and jute of the same size and shape of the deceased worker, put at the same place where he was sleeping and the scrapper operator was told to drive the machine at the same speed and manner at the time of accident. Three trials were carried out and it became clear that it was quite possible to pull the "worker, in that condition.

When this became clearly evident, the remedial measures suggested were : Side guard on both the sides of the front revolving jaws of the scrapper machine after allowing the necessary working depth, Supervision to ensure no resting or sleeping inside the silo. No employment on overtime. Verification by the scrapper operator that nobody is sleeping, before he starts the machine. Hooter blowing before starting, keeping the machine at a safe distance when workers are working in the silo. Stopping the machine if it is unnoticed by someone. Increasing illumination level in the silo and Display of necessary notice.

3.29 Thermic Fluid Fire :

Thermic fluid heaters are now a days in use to heat and circulate hot oil (thermic fluid e.g. Dowtherm) to heat the drying machines or any heating system.

A gland of an outlet valve on hot oil line failed, the hot oil (220 °C) dripped and sprayed on the ground, lagging and insulation burnt of another line down below and fire took place. Six workers were injured of which two died.

The cause of accident was coupling failure and stopping of the oil circulating pump. The oil flow was slowed down for certain time. Therefore the oil was overheated, the gland of a valve burnt and gave way. The leakage took place and the result was a fire.

The remedial measures suggested : Alarm to fireman as soon as oil pump stops to make him alert to throw down the burning coals from fire chamber so that the heating is decreased. Temperature alarm indicating overheating and bypassing the oil from other line at a safer place. Drip collection tray underneath the valve. Checking of glands, seats, spindles etc. at a fixed interval. Standby diesel pump to restart oil circulation at the earliest possible.

3.30 HPCL Refinery Fire at Vizag:

On 14-9-1997, Sunday, a spark entered in a LPG pipeline between the port and Vizag Refinery at Vishakhapatnam, AP and caused heavy fire and explosion. Five officers of Industrial Security Force died and some 20 got burn injuries. It took 12 hours to control the fire. 4 out of 9 spheres (the cost of a new sphere is @ 8 crore) were burnt and the 5-6 km pipeline was badly damaged.

When LPG was being transferred from a tanker on jetty to the refinery pipeline, the pipe burst with explosion and heavy fire spread. 50 T foam was brought from Baroda via air route to fight the fire.

Press reports do not highlight much on causation analysis. How did LPG leak or how a spark of ignition entered the pipeline or how the static charge played its role or how any resistance, friction or cause of fire occurred in a closed pipeline are questions of investigation.

Safety measures needed are periodical testing of pipeline for its strength, joints, corrosion effect and leakage if any, earthing and bonding to eliminate static charge, good maintenance of the pipeline, seamless continuous welded pipe line and no entry to vehicle without exhaust muffler.

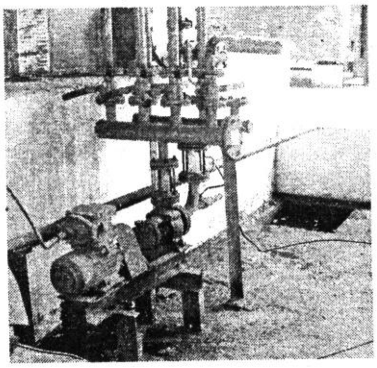
3.31 Common line hazard :

Two rectors wave connected by a common vent line. In one reactor process of toluene was going on. Another was empty and was to be cleaned. By keeping manhole open it was cleaned by hot and cold water. Air was allowed and oxygen level was measured at middle. Vessel entry permit was signed and a worker entered inside. When he sat at the bottom, he became unconscious. Another worker entered inside to bring him out but he also became unconscious and third worker entered.

Cause of accident : Through common vent line .toluene vapour entered in the empty vessel and being three times heavier than air, settled at the bottom and due to its concentrated exposure workers were collapsed.

Remedial measures : '(1) Common vent line should not be permitted. Stop valve on each reactor vent line is necessary. But it requires prompt attention to open, and close. If they are leaky, purpose is not served (2) Oxygen level should be measured at the bottom i.e. at the place of working.(3) Complete isolation is necessary when two such vessels ar(interconnected (4) Safety belt should be used while entering in the vessel.

3.32 Common Header Hazard:



One underground pit was not used since six to eight months. Supervisor told a worker to open its top cover and to put air hose line at its bottom for half an hour to make it clean. On header near wall, there were pipe lines of air, nitrogen, water and steam side by side for utility purpose. By mistake the worker connected flexible hose pipe with N_2 line instead of air line. Therefore the pit was full of nitrogen and oxygen was displaced. When worker entered inside, he died due to oxygen deficiency.

Remedial measures : (1) Clear identification of pipe lines on header (2) Verification by supervisor regarding connection of correct line (3) Air and gas measurement in the pit before allowing a person inside (4) Use of work permit.

3.33 Wrong connection of gas-cylinder:

Chemical reaction of highly flammable solvent was continued under nitrogen blanketing. N_2 cylinder was about to empty. Supervisor told a worker to bring new N_2 cylinder and to connect with the header. By mistake he brought O_2 cylinder and connected. After some time dangerous vibrations of reactor were heard and seen. Violent reaction burst the vessel and due to heavy explosion and fire two workers died and ' the whole plant ruined into pieces.

Cause was the wrong connection. Purpose of N_2 was to keep away O_2. Here O_2 cylinder itself was connected. This accelerated the explosive reaction. Spark was available by spanner and hammer while tightening the bolts which were being loosened and open.

Remedial measures (1) Before connection supervisor must ensure that the right cylinder is being connected (2) Training to workers for identification of gas cylinders. (3) High pressure alarm on reactor and auto draining, venting or safe discharge device.

3.34. Hazards of Plastic Tanks :

Iso propyl alcohol was stored in one 10 T HDP tank. Some alcohol was spilled surrounding the tank. It got spark and fire spread. HDP tank melted due to heat of fire and it gave way. 10 T alcohol was added to fire. The whole plant burnt into ashes.

Remedial measures: (1) It is not at all desirable to fill highly flammable liquid in plastic tanks which can easily melt by fire (2) Leakage and spillage of flammable material must be cleaned immediately (3) Dyke surrounding tank necessary (4) Temperature sensible water sprinklers are useful in controlling fire.

3.35 Filing Order Alteration :

Computerized auto-stop and filing order system was followed to fill benzene in to road – tankers. A rood - tanker of three compartments of 4500, 4000 and 3500 litres was given auto fill order and command to the filling pump to- fill the compartment in descending order i.e. to fill and auto stop at 4500 litres first. This was computer control.

However after starting of the pump, the helper (cleaner) pull out the filing pipe from 4500 litre compartment and put into the 4000 litre compartment. The meter stopped at 4500 litre. Therefore 500 litre benzene overflows and spilled on the road. A driver of the next truck-tanker waiting for his turn nearby, saw this and with a view to reverse his vehicle, applied key to start engine. Benzene vapour was entered in his cabin, ignited by spark from starter, loose terminal or silencer and sudden fire took place. Due to flash back, the tanker being filled also ignited and the helper on the tanker died in this fire.

Cause of accident is a human error to change the fill pipe and failure to understand that it will result in overflow.

Remedial measures : (1) Drivers/helpers must be strictly instructed not to alter the given filing order (2) This will be printed in the filling order slip also (3) Supervisors should watch that truck workers do no change the filling order (4) Benzene detector with alarm to run away in time and to stop the filling pump by a remote stop switch.

4 SAFETY MEASURES TO AVOID ACCIDENTS

To avoid the accidents as described above and others, some safety measures are suggested below :

1. Plan for safety expenditure (budget) at the earliest possible, and invest always sufficient money for safety measures.

2. BIS Handbook and booklets are available for so many standards and chemicals. Safety instructions of these booklets must be followed while storing, transporting, handling and using these chemicals. IS must be followed.

3. See part 6 to 9 of Chapter-18 and Table-4 and other Tables of Chapter-32, to identify chemicals and their hazards.

4. Some known dangerous chemicals are listed in the information of para (2) and (3) above, but 11 still there are many and we do not know the toxicity of majority of such chemicals. Therefore chemistry and toxic effects of all such chemicals must be well studied before storing/using them in your factory. Available standard books must be referred for this purpose.

5. Many factories use chlorine cylinders (tuners) and chlorine leakage may cause severe accidents. You are advised to follow detailed safety instruction given in the booklet "Safe Handling of Chlorine (A guide for consumers) by Alkali Manufacturers Association of India, Bombay." Each factory using chlorine cylinder must have ready 'emergency kit' including self breathing apparatus and the workers properly trained to use it.

6. Manual feeding (charging) of dangerous chemicals in vessels shall be replaced by mechanical means and charging device so that human contact shall be avoided. Charge separate chemicals by separate lines and use selector or header valve to allow one chemical at a time. Use charge or measuring vessel and then allow closed and controlled dropping of the chemical in the main vessel or reactor.

7. Use instruments to read, record, alarm and control various process parameters and try to eliminate human errors in control measures.

8. Use automatic gas/fume/flame detector cum warning alarm at set TLV or LEL limits to detect and warn of all toxic, flammable and explosive gas emissions and leakage in your factory. Use continuous monitoring system or manual gas detection tubes for air sampling to assess and record the contamination at various places. Keep record of this with dates, time, place, prescribed safe limit and measured value. See Form 37, GFR.

9. Prepare a list of concentration limits of toxic gases (maximum allowable exposure in ppm or mg/m^3 for 8 hour average) and combustible gases (boiling point, flash point, explosive limits in air and vapour density) of your factory and provide necessary gas and flame detectors and alarms to detect them and also the safety measures necessary.

10. Make a list of gas, fumes, vapour, mist, dust etc. being evolved, discharged, exhausted, liberated or leaked in the environment and also state their control measures taken by you. Provide efficient exhaust system, closed ducting, extractor, hood, chimney, chamber, scrubber etc. to collect, neutralise and discharge them safely. No gas, fumes, dust etc. should be allowed to fly free as far as possible. These should be collected in closed exhaust system, connected with appropriate scrubber to make them ineffective or non-injurious.

11. All pressure and exothermic reactions must be properly controlled by using proper safety valve, rupture disc, pressure regulator, temperature control, heat-source cut off device, pressure temperature alarm, closed ducting and drowning tank after the safety valve or rupture disc if the reaction mass is hazardous, scrubber if necessary and proper injecting device (valve) for quenching chemical to neutralise the reaction mass to reduce its pressure. An automatic feed and temperature control device to cut off the feed (pump) and to start the cooling media (water etc.) should be utilised for automatic safety purpose. Vent valves must be kept open when desired. Drain valve, remote control valves etc. are necessary.

12. In distillation processes, when cooling media (water) stops in the condenser, it may create back pressure and fuming discharge. To control the situation water flow stoppage alarm as well as heat Source cut off device actuated by the stoppage or interruption of cooling media should be

provided. If the fumes of distillate are toxic or flammable, the vent of receiver must be connected with appropriate scrubber or other condenser and long discharge (vent) pipe. The gauges, column, condenser, safety valve, receiver, vent scrubber/etc, must be regularly checked for good condition.

13. Appropriate scrubbers, blowers, neutralisers, incinerators, flare and safe discharge devices ' shall be provided to scrub all toxic, flammable and hazardous gas/fumes evolved or leaked during the process, storage or use etc.

All acid fumes, Cl_2 NO, NO_2 CO, SO_2, SO_3 NH_3 ZO, PH_3 P_2O_3 H_2 H_2S, HF, etc. and organic toxic or flammable gas emissions and leakage in atmosphere shall be scrubbed and discharged below their permissible safe limits (TLV, LC, LEL etc.). Their regular measurement and record shall be maintained as stated above in para (8). The continuous monitoring system to check safe discharge is most desirable.

14. Where toxic or dangerous gases/liquids are stored in big tanks, its pressure/temperature control devices, safety valve, pressure and temperature gauge, level indicators, flow meters, scrubber, incinerator, flare tower, water curtains or fountain valves, leakage or escape alarms, safe vents, gas detector with alarm etc. shall be regularly checked and maintained safe. One spare tank shall be kept ready for emergency bypass with remote operating valves. All pumps, cooling plants, flow meters. DG set etc. shall be kept ready and the operators shall be trained to control the abnormal or accidental conditions. Dangerous gases shall not be stored in much quantity. These are the lessons of Bhopal disaster.

15. Other devices for storage tanks include safety valve, breather valve, safe vent, scrubber with vent if necessary, condenser to cool organic vapour etc.; earthing, flame proof electric equipment if necessary, automatic level indicator, high level alarm or safe overflow device, bund or dike wall of proper dimensions, dump waste drain, toxic or combustible gas detector with alarm, cautionary notice in local language, name of the content with quantity, fencing wiih gate and lock, water showers, fire fighting equipment, personal protective equipment, more than one way to escape, operating instructions, safety rules etc. These shall be provided as per requirement.

16. Efficient and sufficient exhaust devices at the origin of toxic or hazardous fumes, dust etc. shall be provided and maintained properly. Necessary dust collector, cyclone separator, extractor, hood, exhaust' blower etc. shall be provided to draw dust, fumes etc. from the machine or equipment as well as the surrounding atmosphere. Fresh air feeding (ventilating) devices shall be provided for workers.

17. Water-sealing arrangement may be useful to prevent low pressure (below I bar) explosive air mixture. Then arrangement for safe discharge of explosive mixture after removal of water head - shall be necessary.

18. Water blanketing, curtain or fountains with remote valves shall be provided over chemicals of low flash point. Water showers, eye washers shall be provided near storage of acid, alkali and other corrosive materials.

19. In case of power, water and air failure, emergency alternatives shall be provided and properly maintained. By regularly checking ensure constant water supply, power supply, heating, cooling, stirring, vacuum etc. where they are constantly required and keep overhead water tank, diesel generating set, chilling plant, air compressors, alarms, pumps etc. ready for these purposes.

20. All valves, pipe lines, tanks, stairs, safety devices, plant machinery and structure shall be regularly checked and maintained in safe and sound condition. Necessary repair/maintenance shall at once be carried out.

21. By proper and constant repairs and maintenance keep all tanks, pipes, joints, vessels, equipment etc and premises fully safe and sound from leakage, breakage, escape and injury to health and property.

22. Inert gas (N_2) purging shall be carried out in vessel etc. before charging any flammable/ explosive chemical. It may be useful near grinding/crushing of flammable solids. Charging line for flammable liquid shall be extended upto bottom or made limpet coil on the inner surface of a vessel.

23. Flame traps shall be provided to prevent flashback in any closed circuit (pipe, tank etc.) of flammable gas, liquid or air mixture.

24. Steam pressure reducing valves or auto controllers shall be fitted near all pressure user points.

25. Explosive chemicals shall be stored in explosive godown. Reactive chemicals shall be put separate. Low boiling liquids shall be kept in AC godown.

26. Flame proof 'electrical fitting, motors, starters, switches, earthing etc. shall be fitted in all fireprone areas. Non sparking tools shall be utilised. Lightening arrester rod shall not be ' fitted just on the storage tank. It shall be kept at a height and safety distance from the tank. Conical range shall be maintained.

27. Proper cage with interlocking arrangement shall be used with hoist/lift to lift the materials.

28. Sources of ignition shall be kept away from all solvents and flammable materials.

29. Increase roof-height and ventilation (fresh air and exhaust) to minimise air-contamination. Isolate or segregate at far end corner the hazardous or noisy process which cannot otherwise be controlled.

30. Provide remote controls and remote operating valves where necessary. A central telemetric data logging system to give alarm when process parameters like pressure, temperature, level etc. goes beyond permissible limits will be useful. Control penal board with audio-visual alarms and other latest safety devices should be searched and applied as per requirement. All vessel thickness must be measured regularly. First aid and medical facilities including antidotes, drugs etc. must be kept ready. Emergency and disaster planning will also be useful.

31. Prepare a Safety Manual of your factory looking to your own premises, plant, machinery, layout, design, chemicals, vessels, equipment, processes, hazards, precautions and safety measures necessary for them. Include in above safety manual an Emergency Action plan containing three parts - Operating emergency. Fire emergency and Disaster emergency. In Operating Emergency part include staff and means to control small fire, failure of power, water, steam, air, feed or control of chemicals, safety controls, small leaks of gas, chemical etc. and damaging storms without the help of outside agency. In Fire-Emergency part include steps to call for special fire fighting staff for big fire not controllable by your staff alone. In Disaster Emergency part include ways and means to meet with disaster situations such as explosion, tank or line rupture, heavy leakage, flood, hurricane, storm, earthquake, sabotage, riot, strike accident etc. causing or likely to cause great damage to the factory or surrounding. See Part-7 of Chapter-19 for Onsite and Offsite Emergency Plans.

32. All gas cylinders shall be handled carefully. They shall not be thrown down. Proper ramp shall be used to move cylinder trolley. Gas Cylinder Rules shall be strictly followed. See Part 8.4 of Chapter-18 and Part-3.6 of Chapter28.

33. All chemicals shall be properly identified with names, quantity and precautions. Dangerous chemicals shall not store or pass in breakable containers. Provide labels of names, quantity and safety precautions on all chemical products and verify them on raw materials, packing and containers before using them.

34. Display notices including statutory cautionary notices in all work rooms or floors of your factory stating in brief the chemicals being used or present, their hazards, precautions, safety measures and operating instructions. This should be in the language understood by workers working there.

Keep clean, lighted, well-ventilated and in hygienic conditions sanitary blocks, all drinking water centres, lunch room,, rest room, canteen, cloak room, creche room, ambulance room etc.

35. Fire fighting equipment and personal protective equipment of IS quality, shall be kept in sufficient quantity and workers shall be trained and strictly instructed to use them.

36. All workers, chemists, operators, supervisors and Inspector of Factories shall be properly informed all hazards and their control measures in your factory. Notices of hazards in local language shall be displayed for workers.

37. Guards, fencing, interlocking of machines, safety devices and covers etc. shall be properly maintained in safe position. Safety provisions of the Factories Act and GFR, particularly Rule 54, 60, 61 and 102 (applicable schedules) shall always be strictly complied with. Test all lifting machines, pressure vessels and safety devices periodically and keep form No. 9, 10 fell upto date.

38. All statutory forms under the Factories Act and Rules shall be filled regularly after due testing of equipment and examining workers for occupational health and diseases. Their health records shall be shown to .them. Carry out periodical medical health check-ups of all the workers engaged in dangerous operations for occupational diseases and poisoning and maintain Form No. 20, 30, 32 & 33 GFR.

39. Safety Officer shall be appointed as per statutory -requirement and safety committee shall be formed including workers representatives. The committee shall take regular rounds, check working conditions, ask the workers, check the safety records and suggest necessary steps in writing and keep detailed report of all its proceedings and compliance. Welfare Officers shall also assist by meeting workers at their working places and hearing them on the points of safety, health and welfare of your workers. Their useful suggestions will be recorded and utilised.

40. Workers education on safety is most important. Improve their knowledge, training, practice, good habits and discipline to implement safety on the floor level. Arrange regular shop-floor training programme for them. Their unsafe actions shall be minimised as far as possible.

EXERCISE

1. Write in detail note on the Bhopal Gas Tragedy. Your note should highlight the various causes of the tragedy, the net result and even the plus points achieved by this tragedy in the field of future major accident hazard control in India.

2. Explain the importance of accident case studies.

3. **Write Short Notes:**

   (1) The World Scenario on industrial accidents (2) Flixborough explosion (3) The Love Canal (4) Seveso accident (5) Chemobyl Nuclear disaster (6) Fall accidents (7) Gutter accidents (8) HPCL Fire at Vizag (9) Explosion in Induction Furnace (10) Bursting of Jet Dyeing Vessels (II) Electrical accidents (12) Pesticide poisoning (13) Run away reactions (14) Unguarded machinery (15) Operation of wrong switch (16) Toxic exposure (17) Scrapping of worker (18) Common header hazard (19) Wrong connection of gas-cylinder (20) Filling Order Accident.

4. Describe the facts of the Bhopal Disaster in details. Discuss also the causes of this accident and the lessons thereof.

5. Bhopal accident caused worldwide awareness on industrial safety problems and compelled to amend many safety laws'. Comment this statement with examples.

6. State 'lessons of Bhopal' as published. Do you agree to these? Are 'Right to know' and 'Obligation to tell' concepts included in our safety laws? Give details.

7. Narrate 10 safety measures to avoid fatal accidents OR General safety measures to avoid accidents.

8. Describe in detail a fatal accident investigated by yourself. Give causation analysis and remedial measures.

9. 'Purpose of accident investigation is not to punish but to stop its recurrence'. Give your opinion on this statement citing one fatal accident investigation.

Reference and Recommended Reading

1. Safety Circulars of Factory Inspection Offices.
2. What Went Wrong? - Trevor A. Kletz, Gulf Publishing Co., Houston.
3. Lessons from Typical Accidents in the Indian Chemical Industry, ICMA, Mumbai-23.
4. Still Going Wrong! Case Histories of Process Plant Disasters and How They Could Have Been Avoided by Trevor Kletz

CHAPTER – 31

Road and Home Safety

THEME

The main subject of this book is industrial safety as we have seen so far in foregoing 30 chapters. But other safety areas are also connected and total safety of a person includes his safety not only in industry, but also on roads and at home. The sky or space, sea and any other environment are also other areas where safety is necessary. All such .areas are inter-related and there are many general safety principles which are equally applicable to all of them. Here, in this Chapter, we will study in brief two areas : Road and Home safety.

Average yearly deaths in USA during 1992 to 1996, as reported in 'Accident Facts -1997' are as under:

Motor-Vehicle	-	42000	-	45.16 %
Home	-	26000	-	27.96 %
Public	-	20000	-	21.50 %
Work	-	05000	-	05.38 %
		93000		100.00 %

This indicates @78% accidental deaths are due to road or vehicle and home reasons, a major part comparing with work accidents of only 5%. Cost wise also motor vehicle and home injuries incurred 271.8 billion dollars comparing with work injury cost of 121 billion dollars in 1996.

In our country some figures of accidental deaths during 1993, as reported by LPA News and National Crime Records Bureau, Govt. of India, are as under :

Out of 192357 (100%) accidental deaths -

House collapse	-	1127	-	0.6	%
Consuming liquor	-	0871	-	0.5	%
Suffocation	-	0293	-	0.2	%
Snakebite	-	4768	-	2.5	%
		7059		3.8	

If some accidents from fire, poisoning, electrocution and fall causes are added to above figure, roughly 10 to 15% accidents can be considered as 'home accidents (deaths)'.

Considering total of road and home accidents of @ 35 to 40%, this occupies a major part comparing with factory accident of only 0.3%. Error due to 'no' or 'under' reporting is considered common to all factory and non-factory accidents in our country.

This emphasises the need of safety at road and home. Therefore these two areas are highlighted in this chapter.

1. ROAD AND TRAFFIC SAFETY

This subject was so nicely presented, orally and by an article, by Shri P.M. Pant, the then Inspector General of Police, Gujarat state, Ahmedabad, at the Third Gujarat State Safety Conference at Vadodara on 1,2,3, April 1978, and it is so precise and pertaining to the Gujarat State, it is reproduced below with courtesy. Though the statistical figures are, now old, but they are just for guidance and the inference remains the same.

1.1 The Problem of Traffic Safely :

Due to large scale industrialisation and rapid urbanisation in India, number of motor vehicles in our country is increasing at a tremendous rate. This increase in motor vehicles has led to an increasing trend in the number of road accidents and casualties besides problems of traffic congestion in towns/cities. Road accidents pose a serious health problem to the present day and it will go on becoming worse if timely action to tackle this problem is not taken. Road accidents not only result in a huge drain on medical and health resources and human suffering but also to tremendous loss of property, insurance cost etc.

A study of number of persons killed and injured in India and some foreign countries have shown that, although the number of casualties in India was not much as compared to the figures in other countries, the average annual increase in casualties was high in India. The fatality rate per 10,000 motor vehicles was the highest in India i.e. 64 whereas, in most of the European countries, it varied between 5 and 15. This situation requires to be improved and timely action should be taken to arrest the rate of fatality resulting from road accidents. All the agencies. Government and non Government connected with the problem of traffic safety should take up the challenge posed by this grave situation and work earnestly and timely to take preventive measures. Here, it will not be out of place to state that when an incident of murder or that of house breaking with theft takes place there is hue and cry from the members of public and press does not lag behind, but if a death is caused due to road accident or a person looses vital limbs and is incapacitated no soul is stirred. If the road accident is of serious type in which casualties are more, there will be discussion in the press and it is to be forgotten next day. If the fruits of modernisation, increased industrialisation and urbanisation in our country are to be enjoyed the "mass killing" on the road due to motor accidents should be stopped at all cost.

In country like ours, where population of motor vehicles is increasing every year by leaps and bounds they pose a serious problem. Firstly roads, in our country may be in rural or urban areas, are fit only for pedestrian traffic, and at the most un-mechanised types of vehicles. The streets are narrow and increasing population in our country every year leads to congestion. Entry of motor vehicles on these streets aggravates the situation which leads to accident situations. Thus in our country the situation has been created that all types of vehicular (mechanised and non- mechanised) traffic and pedestrians have to use the same carriage way which leads to accidents and traffic delays leading to economic losses which developing country like ours can ill afford.

The problem of road accidents has two aspects, the study of which is required for proper appreciation of the situation namely road accidents taking place in urban areas and those occurring in rural areas including highways. It is observed that as the motor vehicles playing in urban areas are more than the rural areas, number of road accidents reported from urban area is more when compared with that of rural areas. But due to congestion on streets of towns/cities severity in casualties resulting in motor accidents is less than that of rural areas e.g. on National Highways and State Highways outside the limits of towns/cities.

In year to come vehicle population in Gujarat State will increase at a tremendous rate, looking to the rate of industrial progress and wide scale urbanisation in the State. Road mileage in the State will not be in a position to cope up with the rate of increase of vehicle population. This may lead to increase in road accidents which will result in loss of human lives and property.

Thus the problem of "Traffic Safety" is complex and it can only be solved with corporate efforts of all Government agencies connected with traffic, other non Government agencies and social organisations like Chamber of Commerce, Rotary club. Junior Chambers, Lions club etc.

See fig. 31.1 for problems of traffic safety.

1.2 Figures of Gujarat :

Now, if we take the problem as it is in Gujarat State the situation is as under :

Traffic Accidents as reported in six years are shown in Table 31.1:

Table 31.1 : Traffic Accidents in Gujarat

Year	Fatal	Serious	Minor	Total
1971	760	266	3168	4194
1972	884	2667	1529	5080
1973	970	898	4841	6682
1974	1019	926	4019	5964
1975	1106	786	4618	6510
1976	1033	1048	5033	7114

The Road Mileage (length of different types of existing roads) in Gujarat State and motor vehicle population with the rate of accidents per 1000 vehicles are given in Table 31.2.

Table 31.2 : Road Mileage, Vehicles & Accident Rate

Year	Road Milage Kms.	Motor vehicle registered in the State	Rate of accident per 1000 vehicles
1971	34364	147967	28.34
1972	34794	174452	29.03
1973	37513	204762	32.07
1974	38981	249726	23.06
1975	39575	259049	25.07
1976	39885	320186	22.02

It can be seen from the above figures, that though there is a considerable increase in vehicle population in the State and comparatively less increase in road mileage, rate of accidents per 1000 vehicles has been diminishing. However, motor accidents have been increasing every ye'ar.

The study of road accidents from 1971 to 1976 revealed that on average 37% Goods vehicles (Trucks) followed by 13% of public service vehicles (Buses), 8.1 % Auto'rikshaws and in 7.4% cases motor cycles including scooters was involved in motor accidents.

It is further seen in the above study that on average in 70% cases of accidents, the drivers of motor vehicles are at fault; pedestrians are at fault in 9.3% cases and in 5.7% cases the mechanical defects in the motor vehicles were responsible for causation of road accidents.

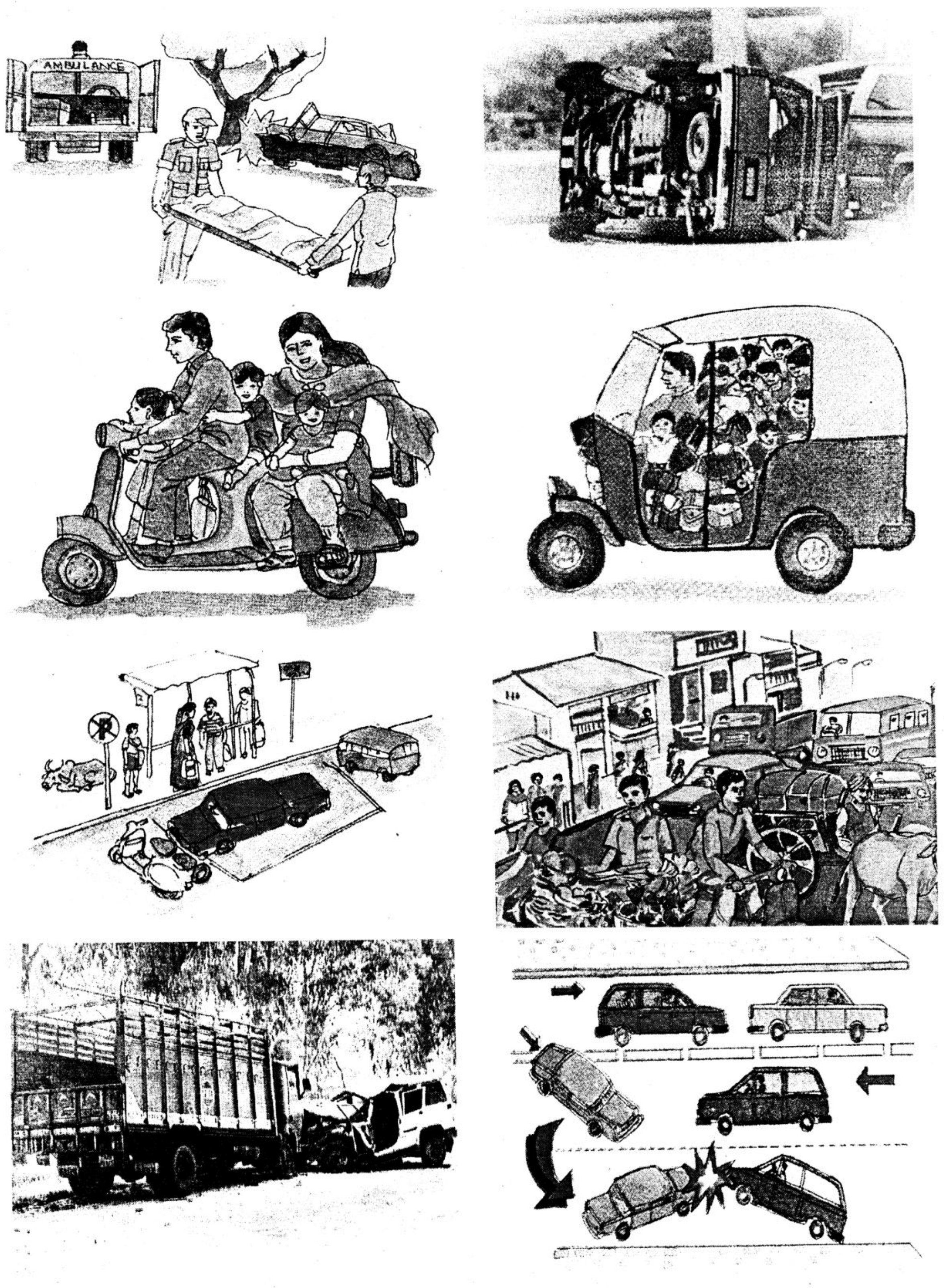


Fig. 31.1 Porblems of road accidents, over crowding, wrong parking and wrong driving.

1.3 Safety Measures:

With a view to minimise the accidents, following measures are suggested which can be classified as administrative, engineering, enforcement and educational measures.

1.3.1 Administrative Measures:

1. At present for Ahmedabad City, there is Traffic Advisory Committee which comprises of representatives of Police, R.T.O., P.W.D., Municipal Corporation; S.T., Chamber of Commerce and other social organisations to meet every quarter to discuss traffic problems arising due to rapid industrialisation and urbanisation. Traffic Advisory Committees on the same lines should be formed for cities like Vadodara, Surat, Rajkot and Jamnagar where traffic problems are likely to become acute in years to come.
2. Government of Gujarat has decided to establish development authorities for cities like Ahmedabad, Vadodara, Rajkot and Surat. They should put more stress on traffic problems of the respective cities and draw master plans to accommodate traffic need of the cities in years to come.
3. Traffic Cells should be started in Ahmedabad, Vadodara, Surat and Rajkot and one at the State level for studying traffic accidents occurring in the State. The personnel of Traffic Cell should visit the places were traffic accidents occur repeatedly and suggest remedial measures. Adequate funds should be made available for speedy implementation of the suggestions of Traffic Cell to achieve desired results.
4. S.T. Central bus stations in cites like Ahmedabad, Vadodara, Surat and Rajkot should be situated sufficiently away from busy traffic areas and local bus services should look after movements of passengers from central bus stations to other 3 localities of towns/cities.

1.3.2 Engineering Measures:

At many a times, bad road conditions are the root cause of accidents. Separate traffic cell should analyse continuously and construct traffic islands, refuges, undertake widening of the roads and removal of blind corners, strengthening of road, improving the road surface, separating pedestrian flow from the vehicular traffic by creating sub ways, pedestrian zones, sufficient foot paths, bus bays, truck terminal out side the city area, parking plots, segregating slow moving vehicles from the fast moving vehicles by cycle tracks in cities, improving road curvature, creating speed breakers on the side roads and fly-over for avoiding junction and crossing. 5

1.3.3 Enforcement Measures:

1. As the number of vehicles in the State are increasing at alarming rate year after year, accidents are likely to increase, it will be essential to augment the strength of traffic police in Ahmedabad, Vadodara, Surat, Rajkot and that of State traffic branch to curb accidents and for achieving smooth flow of traffic in the cities/ towns and on the highways which carry maximum traffic in the State.
2. From the analysis of accidents it is evident that a large number of accidents occur due to the fault of drivers of motor vehicles. This can be controlled, provided die licensing authorities take extra care before issuing the heavy duty licence. The reliability test quick and correct decision etc. of the applicant can be judged by modern instruments. Applicant should have a good knowledge of various road signs. TheR.T.O. should also ensure that the applicant possesses a valid licence for a period of at least 3 years and without any black mark.
3. Mechanical defect in motor vehicles is also one of the major cause of road accidents. Surprise checking of vehicles especially goods vehicles and public service vehicles should be carried out by the R.T.O. to eliminate un-road-worthy vehicles from the road.

1.3.4 Educational Measures:

"Traffic Safety" is not only problem of Traffic Engineering or Traffic Enforcement. Education has also to play a role in it to achieve desired results. Following measures are suggested.

1. In the curricula of primary schools and secondary schools an independent subject of road safety should be included so that children are taught lessons of road safety at an early age. This will prevent injury and fatality in children. They will also become disciplined good citizens of tomorrow.
2. Activity of R.S.P. (Road Safety Petrol) should be put on sound footing on the basis of A.C.C.; Jr. N.C. or N.S.S. so that students participate with adequate enthusiasm and pay more attention to it.
3. Social and cultural organisation like Junior Chambers, Rotary Club should come forward and take active part and render all possible assistance in the efforts of police for traffic management.
4. Traffic warden scheme which is successfully working in Ahmedabad City should be extended to other towns/cities of Gujarat State with a view to associate members of public for managing and convert it into the scheme of community welfare.
5. Leaflets and brochures mentioning various road safety measures should be distributed at all public places to inculcate better road sense in all categories of road users. Films, slides and hoarding on the subject may also be prepared for wider impact
6. Children traffic parks in cities like Ahmedabad, Vadodara, Surat and Rajkot is a must to educate children in traffic rules at an early age.

Thus it can be concluded from the above mentioned facts that in years to come problem of "Traffic Safety" is going to be acute and it requires timely action on the part of not only of police which is responsible primarily for traffic management and prevention of traffic accidents in the cities/towns and rural areas but all the Government agencies like P.W.D. Town Planning Department, R.T.O., "State Transport Authority, Municipal Corporations/ Municipalities and contribute and fulfil their obligations towards society in general and promote interests of road users who are likely to be the victims of road accidents in the years to come. The task is of such a vast magnitude that Government agencies alone will not be in a position to achieve the desired goals for traffic safety, it will need active cooperation, of other non-Government agencies and their active participation for the interests of members of public.

1.4 Accident Statistics & Trend

The IGP Shri Pant's article is over here. The figures therein are 25 to 30 years old. Let us see some subsequent scenario.

Data of 1996 Motor-Vehicle accidents in USA, are as under:

Deaths	43300 (46% of all causes deaths)
Fatal accidents	38200
Disabling injuries	2600000
Costs	$ 176.1 billion
Death rate per 108 Vehicle Miles	1.76
Death rate per 104 Registered Vehicles	2.07
Death rate per 105 Population	16.3

Further break-up is given in Table 31.3.

Table 31.3 : Road Accidents during 1996 in USA

Type of Accident	**Deaths**	**Nonfatal Injuries**
Collusion with –		
Pedestrian	6100	80000
Motor-vehicles	19300	2000000

Railroad train Pedal cycle Animal & animal Drawn vehicle Fixed object Non collision	400 800 100 12000 4600	2000 49000 9000 340000 120000
Total	43300	2600000

Source -.Accidents Facts. 1997. NSC. USA

Thus the motor vehicle fatalities has continued t be the leading cause of accidental deaths in USA. Work accident deaths are 5% and road accident deaths ai 45% i.e. nine times more!

Table 31.4 gives accidents and fatalities rates i selected countries.

Table 31.4: Rates of Accidents and Fatalities in selected countries

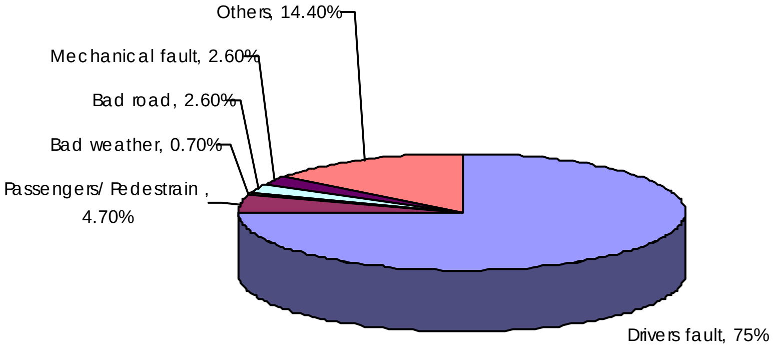
Sr. No.	Country	Accidents per thousand vehicles	Fatalities per thousand vehicles	Fatalities per thousand accidents
1	Australia	3.11	0.39	125.52
2	Brazil	1.38	0.32	229.51
3	France	8.70	0.40	50.00
4	India	13.00	2.61	200.00
5	Italy	11.50	-	31.00
6	Japan	9.80	0.20	18.00
7	Sweden	6.80	2.70	33.00
8	UK	14.00	0.39	24.00
9	USA	12.20	0.33	25.00
10	West Germany	13.30	0.61	34.00

Table 31.5 gives road accident statistics of our country.

Table 31.5 : Road Accidents in India

Year	No. of Registered Motor Vehicles ('000)	No. of Accidents ('000)	No. of Accidents per 1000 vehicles	No. of persons killed ('000)	No. of persons injured ('000)	Total 5+6
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1970	1401	114.1	81.44	14.4	70.1	84.5
1971	1865	120.2	64.40	15.0	70.7	85.7
1972	1865	122.3	59.80	16.1	76.4	92.5
1973	2045	121.6	57.66	17.6	79.3	96.9
1974	2327	114.3	49.11	17.3	76.7	94.0
1975	2472	116.8	47.25	16.9	77.0	93.9
1976	2700	124.7	46.20	17.8	82.5	100.3
1977	3260	135.4	41.53	20.1	95.6	115.7
1978	3614	146.3	40.48	21.8	99.5	121.3

1979	4059	144.4	35.58	22.6	102.9	125.5
1980	4521	153.2	33.89	24.6	109.1	133.7
1981	5391	161.2	29.90	28.4	114.0	142.4
1982	6055	166.2	29.90	28.4	114.0	142.4
1983	6973	177.0	25.38	32.8	134.1	166.9
1984	7949	195.0	24.53	35.1	56.2	191.3
1985	9170	207.0	22.57	39.2	163.4	202.6
1986	10577	215.5	20.37	40.0	176.4	216.4
1987	12618	234.0	18.54	44.4	139.0	234.4
1988	14818	246.7	16.65	46.6	214.8	216.4
1989	16920	270.0	15.96	50.7	229.7	280.4
1990	19152	282.6	14.76	54.1	244.1	298.2
1991	21374	294.0	13.76	56.6	257.2	313.8
1992 (P)	23507	259.3	11.03	57.2	270.0	327.2
1993 (P)	25505	279.3	10.95	60.8	289.7	350.5
1994 (P)	27660	315.7	11.41	64.0	312.1	376.1
1995 (P)	30287	300.6	09.93	55.3	307.1	362.4
*P = Provisional						
Courtesy : Industrial Safety Chronicle						



World-wide @5 lakh people die and 15 million are injured every year in road accidents. The death toll is twice that in industrial accidents. More serious point is that mostly the age group below 25 is involved in such accidents.

It is reported that in 1997 there were 64000 deaths due to road accidents in India and it was second in this record in Asia (News 5-10-1998).

At every 12th minute one accident happens on road. As per figures collected by the Indian Orthopaedic Association, in 1996, there were 72000 deaths due to road accidents. Other figures were as under :

Year	Road Accidents	Deaths
1991	293501	56596
1992	286097	60595

The Presiuent of this Association, Dr. N.M. Lad told that poor maintenance and driving facilities have increased the road accidents (News 11-11-1997).

Figures published in 'Road Safety Digests' of LPA, Mumbai, are as under :

Vehicles Population would exceed 53 million by 2001.....

Every 2.75 minutes, one accidental death in India.....

27.2% of accidental deaths by road accidents .....

Every year @ 40 accidents occur at rail crossings.....

51855 lives lost due to road accidents in 1994.....

India, the THIRD most accident prone country in the World.....

India with traffic fatalities currently (1996) at 60000 per year tops the world in the number of road fatalities. 23 metropolitan cities account for 15% of the total road fatalities in India.

Killing rate increased to 70000 people per year in 1997. More than 3.5 lakh road accidents were reported in 1997.

The economic loss due to road accidents is over Rs.5000 crores. The social, emotional and psychological cost is immeasurable.

Therefore a Road Safety Cell in the Ministry of Surface Transport was set up in 1986 and the National Road Safety Council in 1987 to reduce these losses.

Three years' comparative figures are as under :

Year	Road Accidents ('000)	Vehicle Population ('000)	Rate of Accidents (per 1000 vehicles)
1990	282.6	19152	14.76
1991	294.4	21374	13.77
1992	275.9 (P)	23507 (P)	11.74

Figures of three metro cities, as per Traffic Police source, are as under :

Metro City	Deaths During		
	1994	1995	1996
Delhi	1379	1981	2195
Bangalore	587	678	715
Mumbai	316	372	397

Because of better road conditions and traffic sense in Mumbai, its death toll seems to be less. Even then violations of traffic rules were increased from 15 lakh in 1992 to 28 lakh in 1996 in Mumbai. A senior traffic police officer attributed the problem to the increasing number of vehicles on cit\J roads. In Mumbai, more than 70000 vehicles were registered during one year, 1996, only, the sources added (News 28-8-1997).

Total road vehicles have increased from II million in 1986 to over 21 million in 1991 and the faster growth is still continued due to liberalisation.

The Surface Transport Minister Shri H.N. Yadav told in Loksabha on 21-8-2000 that during last 50 years vehicles have been increased 130 times in the country against the road length increase of only 8 tunes during the same period. 'Every year 40 lakhs new vehicles are registered" he added (News 22-8-2000).

Figures of road accidents in Surat in Gujarat are as under :

	1994	1995	1996	1997
Deaths	115	154	123	167
Injuries	931	1507	1349	--

It is reported that in Gujarat at the time of its separation from Maharashtra, there were only 15000 vehicles. With the rise of 1 lakh vehicles every year, this figure has crossed 28 lakhs vehicles in Gujarat in 1997.

Table 31.6 indicates 10 times increase in vehicles population in Gujarat during 18 years (News 22-31999).

Table .31.6 : Increasing Vehicles in Gujarat

Type of Vehicle	1980	1990	1997	1998
Motor-cycle & Scooter	241165	1257826	2639731	3135791
Auto-riksha	31053	98917	164272	196548
Jeep	14328	33796	66368	78618
Motorcar	52817	141584	285904	338717
Other Vehicles				
TOTAL	458504	1840344	3776973	4470536

As per RTO source, 40000 new vehicles are being added every year on the roads of Surat. In the registration of new vehicles, Ahmedabad is at the top, Surat second, Rajkot third and Vadodara fourth in Gujarat. In India, first, second and third rank goes to Maharashtra, Delhi and Gujarat in this regard (News 22-9-1997).

Vehicles increase in Surat is reported as under:

Type	1984	1999
Car-Jeep	10698	59588
Autorikhsa	4684	29180
Tractor-Taxi	4891	11915
Truck-Tanker	5109	11461
Scooter-Bykes	65636	505233

Total vehicles in the city were 6,42,293 in 1999. 'New integrated public transit system will be needed to tackle the situation that may arise in 2020. (News 8-1-2000).

As per National Crime Records Bureau, there were 3.61 lacs road accidents in India in the year 2004. Average one lac people die every year in road accidents and loss of Rs. 55,000 crores incurs to the Govt. treasury (News 21-1-2008).

See Part-3 of Chapter-1 for industrialisation and road accidents.

Increasing vehicles on roads not only increase the accidents, but it also increases hydrocarbon emissions, air and noise pollution, damage to roads and their repair costs. If the costs of road accidents are combined with these figures, the total will be fantastic.

Exhaust gases from diesel vehicles contain Poly cyclic Aromatic Hydro carbons (PAH) which are capable of causing cancer. Their particle size is less than I micron reaches into lungs very easily and causes damage.

The transportation of hazardous chemicals and heaviest material (e.g. steel plate coils, cable drums, vessels, big box containers, long tankers and trailers) by road is day by day increasing. They are like mobile bombs on highways. They hamper the traffic, damage the roads heavily and in case of leakage, fire or explosion they add to more serious accidents on road.

A report of the CRRI (Central .Road Research Institute, New Delhi) team, comprising of Dr. S.M. Sarin, Dr. Nishi Mittal and Mr. B.L. Suri, published in Road Safety Digest of 1996 (Vol. 6, No. 4), highlights as under:

1. Higher human and vehicle population in 23 metros as compared to India as a whole.
2. Fast spreading cities, inadequate transport. supply and rising incomes are causing two wheeler explosion in all metro cities and accident risk is quite high: in such cities.
3. Heavy vehicles as well as fast speeding vehicles are the main culprits for causing road accidents.
4. The Non-Motorised Transport (NMT) road users consisting of pedestrians, cyclists and other slow-moving vehicle riders are the most vulnerable group involved in road traffic accidents.
5. Most productive age-group persons are killed in road accidents in Indian cities causing huge economic losses to the country and social suffering.
6. The dark hours and the early morning hours are found to be more accident-prone as compared to the day hours.
7. The traffic violations are increasing.
8. The traffic law enforcement has gradually been deteriorating during the last two decades.
9. Fear of penalty is very low in majorities of our cities. Court procedures are slow and very time consuming.
10. Accident recording and investigation work is not a part of the traffic Police function but of the general Police in most of the metro cities.
11. Road safety education is not given due emphasis and whatever little emphasis exists, it is without any scientific basis.
12. Parking problems are getting compounded due to unplanned developments leading to many safety and environmental problems.
13. Encroachment of roads and footpaths is taking place with impunity without any considerations for its adverse effects.
14. Mostly the traffic control devices like signs, signals, markings, etc. are badly lacking, incorrectly installed or ill-maintained.
15. Planning and management for handling road safety problems are poor.

1.5 More Safety Measures:

Some new safety measures to control road/rails accidents are reported as under :

1. Alarm system for unmanned level crossings has been developed by the Bharat Electronics Ltd. This unique accident prevention system switches on a red flashing light and an audio alarm when

an approaching train is 2 km away from the level crossing. The alarm system is reliable and works round-the-clock in any kind of weather.

2. Three types of Traffic Signs have been developed - Mandatory signs. Cautionary signs and Information signs.

   Motor Vehicles Act 1988 requires that a driver should drive the vehicle in conformity with the indication given by the Mandatory Signs. It is an offence not to obey these signs.

   Cautionary Signs are meant for cautioning the driver about hazards- lying ahead on the road. The driver should obey these signs for safety.

   Information Signs are erected on the road to provide information on direction, destination, roadside facilities (e.g. parking) etc. to the road user.

   Road and Traffic Engineering pays vital role in controlling accidents. It includes proper design and construction of road dividers, road surface, pedestrian way, drainage pits, road curvature and super-elevation, traffic signals & signs, road markings, street lighting etc.

3. As per TV advice to the general public. Helmets for two-wheelers and Seat Belts of cars are for the purpose of saving lives and therefore, they must be used while driving. Air bags are also used for the same purpose. Observance of safe speed limits, good maintenance of brakes, tyres, headlights, signal lights and other indicators, horns and reverse alarm, wipers in monsoon and no drug or drink habit while driving are also necessary safety measures.

   Use of cell phone while driving the car can increase the road accidents (News 8-3-1999). It is too dangerous to use it while driving a two wheeler.

4. The vision-screening test carried out by LPA on about 600 transport vehicle drivers revealed that around 45% -of them had visual acuity problems and needed spectacles. Therefore eye-examination for sight perfectness is always necessary.

5. Night driving calls for greater alertness and concentration. At night or while negotiating a tunnel a driver is likely to encounter stretches or shadows on road unlit or poorly lit. He needs time to adjust to the poor visibility and a delay of seconds may lead to a fatal accident. Checking of eye sight, dipped headlights, keeping interior lights off to avoid reflection from windscreens, carrying spare bulbs to remove one-eyed (one headlamp) condition immediately, and paying more attention while driving on built-up areas, rural roads, curves and blind spots etc., are utmost necessary.

6. Auto-dippers are compulsory for all heavy goods and passenger vehicles from March 1996 under the Central Motor Vehicles Rules, 1989. This device dips the headlights automatically.

7. Only sun control film permitting proper visibility and not the dark tinted glass should be used.

8. No child should be allowed to sit in the front seat to prevent hitting with dash-board and crushing. In western countries children in front seats are prohibited. In an auto-rickshaw, a child should not be kept in lap, it should be made to sit between two adults or at least on the right closed side.

9. Patankar Committee, set up in July 1994, in Maharashtra, suggested various measures to prevent road accidents. It includes institutional, legal and regulatory reforms and four Es, namely-
   Engineering actions for safer roads,
   Enforcement of traffic rules,
   Education for safe driving, and
   Evaluation after accidents.

   The Committee also suggested inclusion of 'road discipline' in school education.

10. Catalytic converters are now mandatory for .all new cars to reduce vehicle pollution. Main pollutants are CO, No, hydrocarbons and lead particles. 70% of new vehicles manufactured are 2 and 3 wheelers. Four stroke engines cause less pollution than two stroke and diesel fuel causes less pollution than petrol.

However warning is published in 'News, Bridgs, COEH, June 2000' that the potential health risks of exposure to diesel exhaust are Very high - higher then the health risks of many carcinogens that are already regulated in California, said Allan Smith, professor of epidemiology at UC Berkeley.

11. Regular checking of emission levels of all vehicles and to display PUC (pollution under control) certificate in the vehicle is necessary. Leaded petrol (tetraethyl lead) affects brain, CNS, baby teeth and IQ. Therefore unleaded petrol is recommended. Diesel fumes cause asthma and allergies as reported in Australia. CNG (compressed natural gas) causes less pollution and is safer. See also para 22 for CNG. Electric cars can make the pollution zero. US Clean Air Act has demanded this compliance from car makers.

12. Device to call for help automatically when a car overturns on a lonely road or midnight, is invented. This system automatically dials the emergency services and also identifies where the vehicle has crashed, using the global positioning system (GPS).

13. Electronic Cameras used by traffic police can catch speeding motorists or chit-chatting lovers in vehicles on highways. It is useful in detecting and penalising for such types of traffic violations.

14. A study carried out by the Central Road Research Institute (CRRI) in Delhi, Indore and Bhopal to know the status of compliance of statutory road safety rules revealed that –

(1) Over 50% of the drivers were illiterate or had a primary education only.

(2) 64% drivers admitted that they had no training regarding handling or transportation of hazardous materials. 36% drivers were given a training of one or two days (mostly employed by Government undertakings) and 90% of the trained drivers were not given any further training or refresher course and not satisfied with the adequacy of their training.

(3) The vehicles were not found equipped with firstaid, fire extinguishers, hand gloves, goggles and protective clothing, spark arrester for flammable material etc.

(4) Most of the drivers were unaware of the nature of risks involved, even not knowing the name of the chemical being transported by them. Emergency Information Panel (EIP) was not displayed, or was incorrect, incomplete or misleading where it was displayed.

(5) Only 24% drivers were carrying a relevant TREMCARD (Transport Emergency Card). More than 90% of the drivers were not knowing the utility of the TREMCARD.

(6) The drivers told that the traffic police were also unaware of these statutory requirements for vehicles carrying hazardous goods as they were not facing such technical inquiries.

(7) Most of the drivers frankly told that they would prefer to run away rather than take risks to inform police to avoid harassment from police or general public.

The conclusion of this survey highlights the high need of selection and training of drivers, traffic police and fire brigade personnel about transportation of hazardous materials on road. Only road worthy vehicles and competent drivers should be given licences. On-going intense drivers training programmes and awards should continue.

15. Proper reflectors help to prevent road accidents. Rule 104 of the Central Motor Vehicle Rule, 1989 has made this requirement compulsory. It was observed in one survey that 40% accidents in the night occur because of absence of proper reflectors. Vehicles, more than 6 m. long, should

have reflector area 28.5 cm2 or more and in case of other vehicles it should be 7 C1112 or more.They should be fitted at the proper position.

16. Indian Roads Congress (IRC) has published specifications and recommendations for Hoarding on roads. Some are as under :

(1) No hoarding should be placed at or within 100 m of any road junction, bridge or crossing so as to ensure safe movement of pedestrians and vehicles.
(2) On flyovers, no hoarding should be allowed within '250 m. of the road approaches on both sides.
(3) No hoarding should be allowed on footpaths, curves of roads and any other places where they are hazardous to traffic, or obstruct the path of pedestrians and hinder their visibility at crossings.
(4) The advertisements must not offend public morals and decency. Hoarding should be aesthetically acceptable and should never be obscene or vulgar. They distract the attention of the drivers and pedestrians and cause accidents, and also obscure the traffic control devices like signs and signals.
(5) Hoarding cause glare problem and impair effect of historical monuments etc. Their sizes are also prescribed.

But the survey findings show that almost 80 to 90% hoarding are unauthorised and violating above mentioned safety rules. If this trend will continue, no space will be available for effective traffic control devices. Therefore these rules must be implemented strictly.

17. Retro-reflective sheets and tapes (IS specified) can be used for vehicles, road signs, accessories, rail-road crossing barriers, poles etc. for ensuring safety and smooth flow of traffic.

18. An overhead High Speed Tram System (HSTS) and a Mass Rapid Transport System (MRTS) on railways are planned for Delhi to ease the chaotic traffic situation. Such costly alternatives will reduce the road accidents, traffic density, traffic jams, pollution and road damage all at a time.

19. Helmet Wiper is designed to keep the visor surface clean of water and dust while driving. It can work by a tiny battery operated motor or by the bike's electrical system.

20. Electronic alarm is designed to alert a driver when he falls asleep. The device operates when the frequency of eyelid blinks diminishes. Even if the sleep is not broken by the alarm voice, the device will throw a blast of menthol and lemon scented gas.

21. Malawi, a South African country, had the world highest vehicle death rate i.e. 200 deaths per 10000 motor vehicles. Main causes identified (in 1985 & 1986) with the percentage of total accidents are as under :

1.	Losing control	-	17.5
2.	Crossing without looking	-	11.7
3.	Following too closely	-	9.2
4.	Reversing negligently	-	7.0
5.	Road condition	-	5.3
6.	Overtaking improperly	-	4.9
7.	Misjudging clearance	-	4.9
8.	Failing to keep near side	-	4.6

9.	Falling from vehicle	-	4.2
10.	Excessive speed	-	4.0
11.	Animals on road	-	3.9
12.	Mechanical defect - brake	-	3.9
13.	Learner drive	-	3.3
14.	Dazzled by oncoming lights	-	2.7
15.	Non-compliance of traffic signs & signals	-	2.3
16.	Influence of drink or drugs	-	1.9
17.	Swerving	-	1.9
18.	Mechanical defect - Tyres	-	1.9
19.	Turning right without care	-	1.8
20.	Any other negligence	-	1.6

Despite lack of clear cut definition of above causes or error in exact classification, these causes are good enough to understand the causation analysis of road accidents.

A road safety programme project was undertaken by a team headed by a road safety specialist in 1992, with the following road safety areas :

1. Planning'& Programming.
2. Accident Analysis & Research. .
3. Information & Evaluation.
4. Driver Training & Licensing.
5. Traffic Law Enforcement.
6. Vehicle Testing & Control.
7. Vehicle Registration & Licensing.
8. Road Infrastructure & Environment.
9. Vehicle Overloading & Control.
10. Emergency Medical Services.

This seems to be a comprehensive road safety programme useful to any country, to reduce the road accidents. Working hours and resting time for drivers also need attention. They should be most reasonable to reduce accidents and their health effects.

22. Fuel like kerosene should not be used in automobiles. This is not only illegal but also very hazardous to travellers and the public.

LPG as fuel is permitted and LPG Gas stations are also available. But it should be handled with care. Only authorized LPG kits should be used in vehicles.

Use of CNG (compressed natural gas) must be encouraged. CNG is lead free, contains 80 to 90% methane, lighter than air and not combustible below 5% or above 15%. So the chances of its burning are much reduced. Its ignition temperature is much higher than petrol, making it difficult to" ignite. CNG is stored at 200 bar in a cylinder and can be refilled at gas filling stations (yet to develop in India). Safety valve and rupture disc are provided on the cylinder. Vapour bag carries the leaking vapour. Isolator valve disconnects the supply when engine is stopped. Operational and maintenance costs of CNG are relatively lower. CNG gives better mileage than other fuels. Thus CNG is more safer, cheaper and eco-friendly fuel. Twowheelers to multi-wheelers should use CNG to keep environment clean and safe CNG filling stations should be increased in cities and on highways.

23. High-tech new technology may be used for the smooth flow of traffic. It includes (1) A Radar Gun to record the speed and a number of an erring vehicle (2) Close Circuit Video Monitors to

record vehicles breaking signal rules and (3) A Periscope Van to see vehicles which cross the road-dividers. This system is planned for Delhi roads.

24. Crash-guard for 2-wheelers is designed by Shri BK Jha of CMRI. This device, costing onlyRs. 1000, does 3 jobs at a time on collision with an object : (1) It stops the engine (2) Works as a shock absorber to cushion the impact and (3) Activates a wheel mounted emergency stand to prevent overturning. This device can be in-built or attached as an accessory.

25. Battery powered bus is developed by BHEL to eliminate toxic emission as no oil/fuel is used.

26. Air run car can run by air pressure and not by any fuel (petrol, diesel or gas) is put in a show room in Paris, France. Know as 'City Cat' it runs with air pressure of 300 atm. It causes no pollution (News 15-11-02)

27. Auto Brakes are designed using Autonomous Intelligent Cruise Control (AICC) to prevent driving too close to the car in front, dangerous curve, fog etc. An infra-red laser constantly scans the road ahead for obstacles and passes signal for automatic application of .the brakes. The driver has to steer only. Similar other system gives audio-visual alarms in near distances.

28. Like in US, a highway fund based on motor fuel taxes, may be useful to construct multiple lane • highways to reduce road accidents and traffic problems.

29. Auto pollution figures are fantastic. An US report of 1980, stated that 60 million tonnes of CO, 6 million tonnes of NO, 12 Million tonnes of hydrocarbons and I million ton of soot were emitted by vehicles in USA. The situation is worse in India. Our Central Motor Vehicles Rules, 1989 prohibit such emission of vapour, smoke, ashes, oil mist and noise from vehicles. When we shall comply with this? Electric vehicles, CNG or lead free petrol, use of 4 stroke engines instead of 2 stroke and use of diesel or CNG vehicles instead of petrol vehicles, or use of catalytic converters can solve this problem. Delhi report says tHat the vehicles pollution alone contribute 64% of the total pollution, amounting over I million Kg daily and affecting lungs of @ 30% of Delhi's population. Therefore the Delhi Government has introduced new emission norms as under :
   (1) All vehicles having two-stroke engines will be banned.
   (2) Usage of propane in all three wheelers will be compulsory.
   (3) All diesel vehicles will have to be fitted with a diesel converter.

30. Intelligent Transport System (ITS) is under design for Asia and Pacific region. It consists of sensors embedded in the road to record every movement of the vehicle and to inform drivers about the traffic conditions ahead.

31. Active Cruse Control System uses Radar to maintain safe distance from obstructions in front. It automatically stops or slows down a moving car. It stops wrong overtaking also (News 19-2-2008)

32. Accident Reporting makes it easy to ascertain accident causes and to evolve effective road safety measures based on facts.

French experts on fertility have said that "Professional drivers become impotent, because of long driving." In 'Human Reproduction' journal of European Society of Human Reproduction and embryology, it is reported that the temperature of testis of male drivers increases because of their long sitting on stearing. This adversely affects the sperm and reduces their fertility (News 21-6-2000).

1.6 Defensive (Safe) Driving :

Above mentioned safety measures are incomplete without safety rules for defensive driving. Therefore they are summarised in this part.

As mentioned in a LPA booklet 'Defensive Driving for Safer Motoring', Defensive driving is anticipating situations/factors that can possibly lead to accidents, manoeuvring your vehicle in a way that enables you to stay out of the majority of accident prone situations. Safe driving is not a matter of luck. It requires positive efforts. It is a code of -safe practice of driving. Other abstract of the LPA booklet is as under:

1.6.1 Fundamental Traffic Rules :

1. Keep left. Allow traffic \in die opposite direction to pass you on the right.
2. Overtake only on the right.
3. Overtaking on the left is permitted only when die car in front is about to turn right.
4. Overtaking is not permissible if it is likely to cause inconvenience or danger to the other traffic or where the road ahead is not visible.
5. When being overtaken or passed by another vehicle, do not increase your speed or try and prevent the other vehicle from passing you.
6. Slow down while approaching intersections, road junctions or road corners. Enter the intersection or junction if it does not endanger anyone.
7. When entering a main road from a junction give way to the vehicles proceeding along the main road. Give way to all traffic approaching the intersection on your right hand. If there is a 'Dead slow-major road ahead' sign, yield right of way to the vehicles on your left also.
8. Drive slowly when passing a procession or when 'passing road repairs. In any case your speed should not exceed 25 km/h.
9. When turning to the left, drive close to the left hand side of the road.
10. When turning to the right, draw to the centre of the road, stop, if necessary, at the intersection, then move to the left half side of the road you are about to enter.

1.6.2 Avoidance of Drinks and Drugs :

Apart from legal problems, drinks and drugs lead to any one or all of these

1. Loss of power to judge speed of your car and speed of other vehicles.

2. Loss of power to judge safe distance for overtaking or stopping.
3. Dilation of eyes resulting in poor vision.
4. Slower reactions.
5. Replacement of normal fear of consequence by over-confidence leading to foolish chances being taken and
6. Temporary loss of knowledge of safety rules.

1.6.3 Allow right of way. Follow lane discipline & Prepare for unexpected :

1. Always Give Right of Way

Right of way is defined as a "a privilege of the immediate use of the roadway". These rules spell out who should be where, when and which vehicle should yield to another vehicle at any particular time or place. You know that you never have the right of way until another driver yields it to you.

Give right of way to all vehicles on your right at all times. When entering a road intersection, if there is a "dead-slow-major road ahead" sign, yield right of way to vehicle approaching you from your left also.

2. Follow Lane Discipline

As a defensive driver, you must follow lane discipline. Lane markings do two important things. They ensure that the available road space is used to the best possible advantage and they guide traffic on the path of safety.

Every road has lanes, whether marked or not. Where they are not marked, divide the road into appropriate lanes in your mind's eye. Plan your course so that sudden changes are avoided and never move from one lane to another without good reason. A defensive driver never weaves in and out of lanes.

3. Expect the Unexpected

Be prepared to meet all kinds of drivers during the course of a day. Their driving leaves much to be desired and they frequently confront you with an accident prone situation in which you must constantly adjust your driving to avoid an accident.

You, the defensive .driver, cannot assume that the other driver will be as considerate as you are and that he will respond to the traffic rules as you do. On the contrary, if you expect reckless, illegal and thoughtless actions from the other driver, you will be better prepared to adjust your driving so as to prevent accidents.

1.6.4 Avoid Collision:

To avoid Collision with

To avoid Collision with

Vehicle Ahead	Stay alert, Think of situation, Keep distance, Slow down early
Vehicle Behind	Give signal, Slow down & stop smoothly, Allow others to pass
Approa -ching Vehicle	Keep left, Warn by light or horn
Vehicle at Inter section	Slow down, Look both ways
Vehicle while Turning	See curves, Keep left, Don't cut right corner, Give 'turn signal', Let traffic clear, Don't permit overtaking, See into mirror
Over-taking Vehicle	Give way to pass other, Keep left, Slow down if necessary
Vehicle being over-taken	Overtake from right only, See front clear, Judge your speed to be maintained, Sound horn or give light, Accelerate & overtake quickly, Return to left after overtaking

Collisions result in serious accidents. They must be avoided. Short tips are given beloW :

1.6.5 Hints for Petrol Saving:

1. Don''t speed.

The ideal driving speed is 40 to 50 km/h. You can get 35% extra mileage at 40 km/h as opposed to 80 km/h.

2. Ensure proper maintenance

Poor maintenance may increase fuel consumption by 15% mainly due to three factors: low tyre pressure, retarded spark timing and misfire and petrol overflowing into the carburettor. Improper wheel alignment or defects in brake-system can also increase fuel consumption.

3. Maintain correct tyre pressure

A 25% decrease in tyre pressure can cost you 5% to 10% more on petrol and 25% on tyre life.

4. Use gears correctly

Incorrect use of gears can lead to increase in fuel consumption. Start vehicle in first gear only. Use higher gear for starting only if you are in a muddy patch or going downhill. Get into top gear as soon as possible.

5. Avoid rush-hour traffic

Your vehicle engine consumes double the normal fuel on a highly congested road. Take a less congested road even if it is slightly longer.

6. Anticipate stops

Driving with your foot on the brakes can increase your fuel consumption. Anticipate stops and slow down gradually.

7. Use clutch carefully

Unnecessary use of clutch leads to loss of power and petrol. Replace clutch liners immediately if they are worn out. Stop the engine when you stop your vehicle.

8. Idling wastes petrol

If your battery, dynamo, self-starter and fan belt are in good condition, you can easily switch off at halts over a minute and restart again.

9. Don't speed before warming up

While starting, warm up the engine running in neutral. Drive in low gear till the engine warms up. Don't use the choke longer than necessary. Also never park your car in such a way that you have to reverse with the cold engine.

1.6.6 Caring of Car:

The best guide to car care is the operator's manual of your car. The care of your car must not be left to others entirely.

1. Cleanliness;

Wash wheels daily. Clean lamp and other glasses, engine and car interior daily. Caked up mud and oil under chassis could add to the fuel and repair bills.

2. Nuts and Bolts :

Check the mountings of all systems and tighten nuts and bolts periodically.

3. Lubrication:

Use lubricants recommended by the manufacturer. Check lubrication personally. A missing or faulty grease nipple should be replaced. New grease should be pumped in till all the old grease comes out and the new grease peeps out. Oil changes should not be left to mechanics to decide. Check the oil for viscosity by taking a few drops between thumb and forefinger. If the oil is merely black in colour, change only the oil filter element. Many service stations never use an oil can. Insist on it. An oil spray on the under chassis is no proof that your car has really been serviced.

4. Paint:

Mud and rust can eat into metal. Holes appearing on the doors show that the water drain holes are blocked. Check floor drain holes too. Paint both sides of the floor board and the inside of the doors. Similarly radiator tanks and the petrol tank need to be painted.

5. Special Maintenance:

Engine and radiator need topping up. Brakes need adjustments and refilling of brake fluid. Batteries need distilled water and acid. Tyres need correct pressure and rotation.

Look up your car manual for a complete list.

Some parts of a car wear out very fast. The most expensive ones are tyres, tubes, batteries and brake shoes.

Filter elements, fan belts, rubber hoses, sparkplugs, copper/carbon brushes, fuses, bulbs, etc. also require frequent renewals, but cost little.

When summer comes, check all rubbers in the car and replace if required. Check tyres and tubes carefully.

For winter and rainy seasons, frequently check and clean the electrical and ignition systems.

6. Drivers' Training Programme :

4 to 6 hours drivers training programme should cover the following topics :

1. Statistics of increasing road accidents.
2. Nature and, causes of road accidents.
3. Defensive driving techniques.
4. Principles of automobile mechanism, pollution control and maintenance aspects.
5. Traffic control measures including road safety signs, symbols and lights.
6. Motor Vehicles Act and Rules.
7. Emergency response including first-aid.

1.7 Driving for less pollution

About 60% of atmospheric pollution is caused by vehicles alone. Therefore following tips are given to reduce pollution, conserve fuel, extend engine life and save money.

1. Drive less :.

In the metropolitan cities of India, maximum air pollution is caused by cars and trucks. A good way to reduce this is to drive less. Fewer trips in your car or truck will help cut air pollution. Driving less doesn't mean you have to stay home. Try combining driving with other ways of getting where you want to go: Carpool, walk or ride a cycle, shop by phone or mail, ride public transport, telecommute, combine your errands into one trip.

2. Drive smart:

Another way to reduce air pollution is to drive smart. Driving smart can reduce your car's pollution and save energy, - saving energy helps reduce air pollution: accelerate gradually, avoiding 'jack rabbit' starts, stop engine idling at signals, use the clutch to a maximum, obey the speed limits, avoid sudden braking, avoid or drive slowly on unpaved roads.

3. Be an active motorist :

Use unleaded fuel, warn your engine at idle speed before you start your journey, don't top off at the petrol pump, check with the respective oil companies for the authenticity of fuel at your regular filling stations.

4. Maintain your vehicle regularly :

Keep your car tuned and support PUC, clean or replace your car's air filter regularly, keep your tyres properly inflated, get your clutch play adjusted every time you service your car, keep all the fluid levels in the engine compartment to the maximum.

5. Use an alternate fuel :

Whenever you burn a fossil fuel, you pollute the air. Use less gasoline and diesel oil; if possible try and consider CNG conversion.

6. When buying your next vehicle :

Look for the most efficient, lowest polluting model. Always drive your newest car. New r cars generally pollute less than older models. If you are planning to purchase a brand new two-wheeler, this is the right time to do so. All two-wheeler manufacturers are trying to reach the goal of making new vehicles emission-compliant before the deadline of April 2000.

7. Speak up for clean air :

Now that you have learnt how to reduce pollution, let other people know. Support action for clean air. Report smoking vehicles - call the traffic commissioner's office.

1.8 Indian Standards :

Road traffic - lighting 1885, signals 7537, Road vehicles - breaking terminology 9268, pressure 9212, gear positions 9262, symbols for controls, indicators and tell-tables 9237, dimensions 9435, Road and street lighting luminaries 10322, Roadwork measurement method 1200, Vehicles - animal drawn 4930, 12199, 12917, Cables for motor 2465, flexible load bearing PUF components 8255, emission limits for CO 9057, Rims motorcycle 10694, Road denominations and definitions of Weights 9211, noise measurement 10399, Transport - glossary 7774, packages 7028, 7031, 9111, passengers by ropeways 5228, 5229, 5230, of liquefiable gases, steel cylinders 2872, Diesel engines - automotive purposes 10003, fuel filters 3169, fuels 1460, Diesel locomotive for use in mines 9999, Diesel vehicles - smoke emission levels 8118, electronic speed limiters 10144, Test for power take off (PTO) drive shaft guard 8265 (PTO is used for coupling the tractor PTO with the implement).

See also Part 3 of Chapter-23 for other IS.

1.9 Laws on Transportation :

For Motor Vehicles Act 1988 and Central Motor Vehicles Rules 1989 including rules for transporting dangerous goods see Part 6 of Chapter-28. See also Part 14 of Chapter-18 for Transportation of Chemicals.

2. HOME SAFETY

Variety and number of home accidents are many. Injuries going to hospitals or Police records are countable but many remain unreported and unknown. In addition to general causes like fire or burn, falling, slipping, cuts, poisoning, electric shock etc., now another dimension has been added and that is pollution indoor. Mayur Vihar in east Delhi has more polluted air than that outside on roads. SPM detected in that residential area was reported double of that found outside!

2.1 Home a type of Protection :

A man feels the best protection and peace in his home. He tells his home a happy home or slucet home and likes it very much. Generally a man spends his most of the time at two places : at the place of his work or occupation and at his home. This is generally true for most of us except few exceptions. Therefore, it is most desirable that our home should be the most peaceful and pleasant place and at the same time the most safe too. No body wishes accidents or injuries in homes. Yet they take place and make us unhappy.

According to a report of American Consumer Safety Commission, in USA, nearly 200 lakhs people meet with home accidents out of which 30,000 lose their lives and 1,10,000 lose their limbs.

USA figures of 1996 Home injury deaths are as under:

Total deaths 26500, classified as Falls 8200, Fires & Burns 2900, Suffocation 1500, Suffocation (rriech.) 600, Poison (solid, liquid) 7800, Poison (gas, vapour) 400, Firearms 800 and others 4300.

Total disabling injuries (home) were 7300000, death rate per I lakh population 10 and cogts 95.7 billion dollars.

As per the report of Velend Haise, some reasons of deaths were mistake, insecticides or pesticides, and packing without labels.

In our country every year 6 to 8 lakhs burn accidents take place causing about one lakh deaths. In Bombay, yearly burn accident toll is @ 1000. In Vadodara during 1975 to 1979, 2541 persons were admitted for burn treatment. More people die in accidents than in war. The family members and the society are put to a great loss and mental upset due to such home accidents. The reasons of home accidents and their preventive measures are explained below in brief.

2.2 Reasons of Home Accidents :

The main reasons incitide :

1. Carelessness in good housekeeping.

2. Wrong or faulty use of home appliances viz. kerosene stove, gas stove, cooking range, electric heater, pressure cooker, oven, lighter, washing machine, iron, hair drier, fans, radio, TV, tap recorder, vacuum cleaner, grinder/mixture, flour mill, cosmetic instruments, water pump-motor, sewing machine etc.
3. Leakage in gas line, "regulator, fittings etc.
4. Broken or heavily loaded electric wiring, plugs, holders etc. No proper earthing. No ELCB.
5. Broken stairs, floor and furniture.
6. Un-plated vessel causing food poisoning.
7. Non-hygienic or contaminated food.
8. Use of insecticides, drugs etc.
9. Non-earthed electric equipment and damaged switches, plugs etc.
10. Non-maintenance, or wrong use of pressure cooker.
11. Use of breakable glass crockery and putting them in unsafe conditions.
12. Slippery surface in bathroom and elsewhere.
13. Hanging cloths on electric or telephone wires.
14. Keeping poisonous chemicals anywhere within the reach of children.
15. Keeping the eatables open.
16. Not cleaning or sweeping dirt, dust etc. regularly from each room.
17. Keeping flammable substances or source of ignition within the reach of children.
18. Carelessness while cooking and heating.
19. Use of acid and other chemicals in home.
20. Children's play and rushing unsafely or taking anything in mouth, ear, nose etc. or playing with tame animals like dog, cat etc. or flying kites or firing crackers on festivals.
21. Not taking care or first aid in minor injury or unnecessarily avoiding it.
22. Wind and storm. Outside air pollution (e.g. fly ash and gases from factories and vehicles on neighbouring high ways) entering the homes.
23. Rain, flood and swimming.
24. Playing with knife or sharp .edges.
25. Always hurrying or making haste while calling some one or going for buying.
26. Mental disorder or disease.
27. Fighting for toys or games.
28. Tense atmosphere or always under mental tension due to any reason.
29. Wrong layout of office furniture, open drawers, broken chairs, slippery floor, flammable wastes, awkward positions etc.
30. Flying fireworks like rockets, havai and unsafe playing with them.

It is reported that the Central Government has prohibited the production, sale and use of such fireworks (mostly atom bombs) which create noise of more than 125 dB within 4 mt from the point of their firing. In addition to noise pollution fire crackers also pollute the environment (News 20-12-1999).

A list of such home-accidents may be very long and most of us know these reasons. Now the only necessary step is to be conscious and aware to prevent such accidents. Let us determine not to allow such accidents. A little care, teaching and training to family members (particularly to ladies and children) will be most useful.

To prevent food contamination or poisoning due to inferior recycled plastic carry bags or containers, the Central Government has made rules known as 'Recycled Plastics Manufacture & Usage Rules 1999' effective from 2-9-1999. For details see Part 2.38 of Chapter-28.

2.3 Preventive Measures :

2.3.1 General:

Preventive measures include:

1. Use of water and early medical treatment in all cases of burns.
2. Checking electric lines, gas lines and their fittings by a qualified and competent person. Providing ELCB in electric supply.
3. Keeping floors non- slippery and safe.
4. Maintaining good house-keeping. Insist for quick cleanliness. Use vacuum cleaners.
5. Keeping flammable and dangerous things safely and out of the reach of children. Playing fireworks safely.
6. Using all electric, gas and pressure equipment of IS mark with full safety and precautions. Insulated handles of electric home appliances.
7. Avoiding haste and acting calmly.
8. Maintaining full safety in kitchen and bathrooms,
9. Eat always fresh food and do not store it for a longer time for reuse.
10. Identify all drugs and medicines by proper labels and keep them in safe cupboard. Destroy their empty containers.
11. Take medical advice for any disease.
12. Avoid quarrel, friction and tension in day to day life.
13. Develop good habits and safe practices in daily life and general behaviour.
14. Foresee the risks in specific house hold arrangement, find out the means to remove them and apply them.
15. Spread this message of home safety to others also, so that totality of such accidents can be reduced.

2.3.2 Gas Work :

'Safety guidelines to Customers' issued by the Gujarat Gas Co. Ltd. (GGCL) are reproduced below :

Precautions For Daily Operation

1. Before igniting the hot-plate, ensure that there is no gas smell & also ensure that windows of the kitchen are open.
2. Ensure that the rubber tube is in good condition and it is properly fixed with the hot-plate and gas tap.
3. Open the gas tap first, then the knob of hot-plate and ignite the burner immediately.
4. Protect the rubber tube from hot utensils/ hot items.
5. After cooking make a practice to close the gas tap in addition to the knob of hot-plate.

Use of Main Control Valve

1. Main control valve is installed on the pipeline in your premises before meter and regulator. Closing of this valve will stop gas supply into your gas connection.
2. Operate this valve at least three times in a week to prevent possibility of leakage from valve.
3. Close this valve, when your house is to remain closed for more than a day.
4. Before opening this main control valve, ensure that the gas tap in the kitchen is on closed position.

Safe Use of Gas Geyser

1. Proper ventilation in the bathroom is a must.
2. For more safety, first take out hot water and after switching off the geyser, enter into the bathroom to avoid headache, discomfort, unconsciousness etc.

In Case of Gas Smell/Leak in Your Premises

1. Close the main control valve.
2. Do not ignite the hot-plate or any other items.
3. Do not operate electrical switches. Let them remain in as it is position to prevent chances of spark.
4. Do not start any vehicle or equipment in your premises. Cordon the area and alert the people around.
5. Keep open all windows and doors, if the gas smell/leak is inside your house.
6. Inform GGCL immediately and get the gas line checked/repaired by GGCL representative if necessary.

Safeguard Your Gas Installation

1. Do not excavate the soil above the pipeline laid underground in your premises.
2. In case renovation or modification is necessary in the house, get the guidance of GGCL to ensure safety of gas installation.
3. If any modification/extension/replace-ment of gas installation is required; get it done through GGCL only.
4. Do not tie-up anything with gas pipeline and protect it being hit by any object.
5. In case of an unfortunate fire incident at your house, inform GGCL immediately. If main valve is accessible, close it.

Other Information

1. All GGCL representatives have identity cards. Please ensure that the card is checked before allowing entry into your premises.
2. Get the receipt against any payment given to GGCL personnel.
3. Following Annual services are provided by GGCL.
    - Replacement of rubber tube under use once in a year.
    - Painting/reclamping of pipeline as per requirement.
    - Checking of the gas line installation.

Gas Geyser Safety:

Fatal accidents have been reported due to the unsafe use of a gas geyser. In a confined, space of a bathroom, if fresh air inlet ventilation is insufficient and geyser gas outlet pipe is also opening inside the room or it is open flue type, it causes double harm. Oxygen is rapidly consumed by the flame of the gas (e.g. NG or LPG) and its proportion less than 10% (oxygen deficiency) becomes dangerous to life. Also due to gradually diminishing .oxygen, the combustion becomes incomplete and gives rise to carbon monoxide (CO) generation and its level above 2000 ppm (TCL, 650 ppm/45 min) may soon prove fatal. CO is a silent killer. CO, in flue gases helps to increase oxygen deficiency.

If LPG is directly leaking in the bathroom, it accumulates at lower level (vapour density 1.2) and if spark is available it causes fire.

If NG (natural gas) is used, on leaking it goes upward (vapour density 0.6) and escapes from upward ventilation. Thus NG is safer than LPG.

Therefore to avoid both these adverse effects, toxic & fire, it is utmost necessary that

1. Bathroom should be of greater size and have sufficient fresh air ventilation. Ventilators at bottom and top are desirable.
2. Gas-geyser fresh air inlet and flue gas outlet pipes both should open outside the room and at the height possible. Such 'Balanced Flue type Gas Geyser' is more safe.
3. Gas connections should be maintained leak proof.
4. Water should be heated before bath and while bathing the geyser should be kept off or at the lowest gas flow burning rate.
5. In a gas- geyser bathroom, electric fitting should be flameproof.
6. Before bathing the bathroom should be kept open at least for 15 minutes.
7. If you feel breathing trouble, uneasiness or headache .while bathing, immediately open the door and come out in the fresh air.
8. Never open water valve prior to opening of a gas tap. First open the gas tap, ignite the flame and then open the water valve.

2.3.3. Kitchen Machines:

Some safety precautions for commonly used kitchen machines are as under:

(1) Washing Machine:

1. Top cover on the rotating spin tub should be interlocked i.e. the tub should not start rotating till the top cover (lid) is not closed and it should be stopped as soon as the top cover is opened.
2. Hand should not be, put in rotating spin tub or washing tub when the pulsator is moving. Hand should not be inserted under the machine • when it is operating
3. Burning object or flame should not be brought near the machine. It may cause deformation or fire.
4. Do not use hot water (>50°C) directly inside the tub.
5. Prevent kids to climb on the machine and to bow inside.
6. Solvent like benzene, thinner, petrol or acid should never be used for wash/spin process.
7. Water should not be splashed on electric switches. Avoid machine to move here and there.
8. Use 5 amp, 3 pin socket only for 240 V, AC 50 c/s supply. Ensure proper earthing. ELCB more preferable. Plug should fit firmly without loose connection. Supply cord should be pinched by the machine legs or a heavy material. Switched off the supply after use.
9. Fill water till marking only. Use soft water. Do not overload the machine. Keep the buzzer on. Drain properly. Remove coins and metal parts from pockets before putting clothing inside the machine. Keep the floor dry and clean. Wear rubber slipper or use rubber matting to avoid electric shock.
10. Follow manufacturer's instruction strictly.

(2) Freeze (Refrigerator):

1. Keep the plug and earth connection tight, not allowing loose connection. Switched off when not in use. Keep the floor dry and clean. Keep the supply cord in safe condition. Keep the machine position fixed and most convenient to avoid frequent movement.
2. Clean the freeze completely every week or at least monthly by unplugging and defrosting fully and cleaning internally and externally by a mild soap solution and making it fully' dry before restarting.

(3) Mixer - Grinder and Flour Mill :

1. Do not run the machine for a longer time otherwise overheating may damage the motor or electric parts.
2. Supply cable should be kept safe, uncrushed and unbroken. Three pin socket and good earthing are necessary.
3. Moving cutter, pulley-belt, grinding stone or wheel etc. should be fully enclosed.
4. Keep the supply switch off after every use so that children cannot start it.

(4) Toaster:

1. Do not use the toaster for a longer time. Use i after some rest (cooling).
2. Clean the toaster weekly internally anc externally and remove bread-crushings if any
3. Moisture and water damage the heating coil Therefore keep it open for some time after even use.

(5) Microwave Oven :

1. Keep the oven on a wooden table and well earthed to avoid electric shock. Keep it away from water and moister.
2. Use the baking dish and tongs available with the oven. Never use a metal tongs or pair of pincers to put or take the material inside the operating oven. Never put metal dishes inside.
3. Switch off the power before opening the oven and keep the door open after its use to allow natural cooling.
4. Clean inside thoroughly and follow the manufacturer's instructions strictly.

2.3.4. Earth quake :

Preventing measures for earth - quake are difficult as it being an 'Act of God' like cyclone, high tide etc. But preventive measures for damage due to earth - quake are certainly possible. 26 January 2001, at created history. Devastating damage of thousands of deaths, collapse of buildings and communication systems at Bhuj, Ahmedabad, Surat and other parts of Gujarat created worldwide effects. Help from all over the world was reached and need of disaster management was widely discussed. TV, newspapers and all media were full of earth- quake news for day together.

National Earthquake Information Centre of USA measured the gravity of earth quake as 7.9 Rihter (it was initially reported as 6.9) and explained the 'elastic rebound theory' or 'plate striking theory' as a cause of this earth-quake. As it was reported, 23.10 km under the earth, a rock plate was slipped making Bhuj of Gujarat as centre. The shock waves travelled upto Nepal by 3.16 minutes and reached Atlantica by 15.45 minutes.

The most sever effect was on houses and human beings. Homes were collapsed like playing cards. More than 20,000 people were buried under debris and more than that were injured. Reports regarding casualties, injuries and losses were widely varying. One such report of Central Govt. published on 4-2-2001 gives following figures:

People injured	55573
Death	15076
People affected	3.5 Crores.
Property losses	Rs. 13500 Crores
Damage to industries	Rs. 5000 Crores.
Fully broken buildings	73142
Partially broken buildings	142180
Talukas affected	49
Villages affected	949
People engaged in rescue	

activities	25000
Medical aid sent	Rs. 5.7 Crores
Helping countries	38
Help from World Bank	300 million dollars
Help from Asian Development Bank	350 million dollars

The revised report published on 17-2-2001 changed some figures as:

Deaths-18602, People injured-1,66,385. Animals dicd-20712 and estimated loss Rs. 21262 Crores.

The State Government is report published on 72-2001 including following figures:

Fully broken buildings	2,28,906
Partially broken buildings	3,97,538

Thus the gravity of earth-quake is difficult to assess soon and the loss figures 90 on changing for a longer time.

(1) Safety of Buildings against Earth-quake :

Above mishap draws our attention toward home safety. Civil and structural engineering, including stability of buildings and tall structures, is one of the oldest branch of engineering and is fully capable of guiding us for safety in design, construction and maintenance of buildings against earth-quake phenomena. Details should be searched out from it. Some basic precautionary safety measures are stated below:

1. Foundation should be designed after Richterscale reported in past and experts' advices.
2. Load bearing columns, beams and structural members should be properly designed and placed one' over the other to give fully support to each other and withstand vertical and horizontal shock waves due to earth quake.
3. Over head water tanks and other load should be so placed that the load will be uniformly transmitted on foundation. Vibrating machinery or such material will not be kept upstairs.
4. Stair-cases will be of sufficient width, having hand railings and properly designed steps. Emergency exits will be available where required.
5. Early vibration sensors and audio-visual alarm should be provided to detect deep and invisible vibration (ultra sound) in structure. A hanging bell in a bed-room is the simplest device. A vibration sensor attached with foundation wall or ceiling may give first vibration. A few second early detection and alarm can save many lives.
6. Parking pillars should have deep and sound foundation, sufficient section, well reinforcement and good factor of safety to withstand the initial earth waves.
7. Good quality of building material (cement lime, sand, brick, stone, wood, standard, steel etc.) should be used. It should never be used in quantity and proportion less than required. Water cement ratio clean water without salts, proper mixing and proportion of material; curing, settlement and drying time, proper joints and supports ... all are important.
8. National Building Code, Indian Standards, statutory safety rules (See Chapters 22, 27 &28), other rules, regulations and by-laws of the local authority must be followed of drawings and construction, various testing certificates, completion certificate, living permission etc.
9. For high rise or multi-storey building, soil testing before excavation and foundation work and rules regarding limits of height, load and other criteria should be followed.

10. For tall and heavy structure, special design of underground shock absorbers or vibration dampers, detection probe to detect underground deep vibrations and to give alarm, indication of the weakening of the deeper soil etc. should be considered.
11. Earth-quake factors must be considered while constructing heavy chemical or atomic plants, storages, pipelines etc. in quake - prone areas. This will avoid cascading effect i.e. not allowing to mix earth-quake emergency with the emergency as a consequence.
12. Building should be designed and to withstand not only vertical forces but also horizontal forces due to earth-quake.
13. For the stability of the building, weight and volume (area) both should be decreased by 10% with each floor. Such pyramid design keeps the centre of gravity well balanced.

    Water tank on the top should not be too big and should rest on foundation columns or load bearing members.
14. Emergency rescue ladders (viz. rope ladders) must be kept ready at each floor like fire hose reds and nozzles to use them to come down when it becomes impossible to use the regular stair-case or lift etc.
15. As a long-term planning. Disaster Management Organization should be planned to deal with all types of natural disasters (acts of God) like earth-quake. Cyclone, heavy rainfall, famine, massive epidemic etc. This may be at national or state level and should include preparedness activities, disaster-time control activities and post disaster activities. It should be an exclusive organization for this task. It is criticised that such disaster management organization of state or national level will be idle for most of the time and therefore be highly expensive. Equipment and other things may become non-useful after a long time, and heavy budget may be required for updating every thing and maintaining large manpower. It should be kept busy in regular rehearsal.

(2) Some tips for Safety at quake time :

Some common tips for people at home are as under:

1. Inform every family member about safe and unsafe part in every room. Keep the exit ways without obstructions.
2. Don't put heavy articles on top of the cupboards or shelves.
3. Each member should be given telephone numbers of near relatives and friends.
4. Cupboard doors should be kept fastened so that they may not open and inside things may not fall out due to quake.
5. At the time of earth quake do not stand under heavy beam, slab, fan, glass articles or any thing or structure likely to fall down.
6. Keep flammable and toxic material (e.g. pesticides) on floor, at safe corner and away from reach of children.
7. Go to top floor or ground' floor which ever is nearer. Don't use lift. Don't jump from unsafe height.

2.4 Indian Standards :

Domestic pressure cookers 2347, Rubber gaskets for pressure cookers 7466, Domestic LPG installation, Safety Code 12011, Specification for LPG 4576, Safety ' devices for gas cylinders 5903, rubber hose for LPG 9573, flexible 'rubber tubing for LPG 10908, LPG leak detector 13432, Domestic LPG gas stoves 4246, Oil pressure stoves 1342, Safety requirements for high' chairs 6185, for push chairs 6618, Safety requirements for toys 9873, Selection of toys 9849, Abdomen guards for sports use 6974, Safety requirements for household electrical appliances 302, Code of practice for earthing 3043, Safety requirements for mains operated electronic and related apparatus for household and general use 616, Safety and physical planning of computer complexes 11713 (Part 2), Guide on human safety in design, manufacture, use and maintenance of electronic equipment 11743, Safety requirements for floor and wall openings, railing and toe boards 4912, Pictorial markings for handling and labelling of dangerous goods 1260 (Part 1), Safety requirements in electro-heat installations 9080, Guide for handling cases of pesticide poisoning, first aid and treatment 4015, Requirements for packing of pesticides 8190, First-aid dressings 11163, Fire appliance 2190.

Scissors for general purposes 989, LPG cylinders 3196 (Part I to 3), condoms 3701, hair clippers 3743, metal hooks, clips and eyes 4066, snap fasteners for dresses 4108, 4741, paraffin wax 4654, safety pins 4798, skin powder for infants 5339, needles 6321, hair dyes - liquid 8481, powder 10350, plastic potable, water bottles 1988, press button 9719 to 9721, lipstick 9875.

E X E R C I S E

1. "Road accidents are much more than the factory accidents". Discuss this statement with relevant statistics.
2. 'Road safety needs more attention than the industrial safety, even than more laws and more efforts are visible for industrial safety. Give your comments.
3. Who is the proper authority for road safety? RTO, Police or both? Discuss the roles of RTO, Police and NGOs to minimise the road accidents.
4. What is the role of the general public to save themselves from road accidents?
5. 'Self discipline, self control and compliance of law by the drivers is the only best remedy'. Discuss the statement.
6. Discuss the safety points of driving vis-a vis safety points of vehicles.
7. What are the hazards due to vehicles running on roads? What are their remedial measures?
8. 'Vehicles on road contribute highest not only to accidents and fatalities but also to the air pollution.' Discuss in details.
9. 'Problem of road safety is day by day worsening'. Comment with reasons and remedies.
10. What could be the effective action plan to control road accidents at district, state and national level?
11. Discuss the problem of traffic safety.
12. Discuss the types of safety measures to minimise the road accidents.
13. Discuss any four new inventions as road safety measures.
14. Write Short Notes :

    (1) Road safety problem. (2) Engineering measures for road safety. (3) Statistics on road accidents and its conclusion. (4) Educational measures for road safety. (5) CRRI Report on status of road safety problems. (6) Traffic Signs (7) Night driving. (8) Auto-dippers. (9) Catalytic converters. (10) Unleaded petrol. (II) Patankar Committee's Report. (12) Electronic Camera. (13) Reflectors. (14) Hoarding obstruction. (15) Road safety areas suggested by Malawi Report. (16) Crash-guard for 2-wheelers. (17) Auto alarm for railway crossing. (18) Auto brakes. (19) Automobile Pollution. (20) Defensive Driving.
15. State the fundamental traffic rules for defensive driving.
16. State important provisions of the Motor Vehicles Act & Rules for the road safety.
17. Narrate the driving rules to avoid collision.
18. Discuss points of petrol saving or for caring of car.
19. You area teacher for drivers. Please give the topics that you should include in your drivers' training programme.
20. Discuss the problem of Home Safety.
21. Give any 10 reasons of home accidents.
22. Discuss with details on 'Reasons of home accidents and remedial measures'.
23. Give general preventive measures for home accidents OR Discuss the safety points of a gas use in a home.

24. Give details of hazards and remedial measures of 'Gas Geyser'.

25. Write Short Notes:

(1) ELCB for electrical safety. (2) Precautions while using a gas geyser. (3) Pressure Cookers. (4) LPG gas stoves. (5) Electric grinder-mixer. (6) Microwave ovens. (7) Kerosene stoves. (8) Pesticide poisoning. (9) Safety requirements for household electrical appliances. (10) Hair dye. (11) Use of cosmetics. (12) safety from crackers. (13) Plastic carry bags. (14) Kitchen safety.

Reference & Recommended Readings

1. Publications of Loss Prevention Association of India including Road Safety Digest, Road Traffic Signs, Defensive Driving for Safe Motoring, Road Safety Guide for Children, Safe Two-wheeler Driving and Catalogue of Publications.
2. Traffic Engineering & Transport Planning - L.R. Kadivali.
3. The Drivers' Workplace, 1995, The Swedish Work Environment Fund, Stockholm, Sweden.
4. Family Safety-Making Life Safer by JP Gupta, Ratna Sagar Pvt. Ltd., Delhi - 110009.
5. Occupational Therapy and Ergonomics: Applying Ergonomic Principles to Everyday Occupation in the Home and at Work by Franklin Stein.

CHAPTER – 32

Safety Tables

THEME

1. *Elements and Radicals.*
2. *Branches of Chemistry.*
3. *Concise Glossary of Chemical Terms*
4. *Dangerous Properties of some commonly used Chemicals*
5. *Rating Form of Activity Standards.*
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7. *Classification of Pollutants*
8. *Industrial Emissions and Control Summary*
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10. *Pollutants, their TLVs and Health Effects*
11. *Tolerance Limits for Effluent Discharge.*
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15. *Permissible Levels (TLV & STEL) of Certain Chemicals in Work Environment*
16. *Merits and Demerits of some Waste Disposal Methods*
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21. *Angle of Repose of Soils.*
22. *Conversion Factors.*

Some miscellaneous safety tables not included in other chapters and still useful for safety purpose are included in this chapter. They furnish some useful data. Their references are also given in the foregoing chapters.

Table-1 : Elements and Radicals

Some Common Elements :

Aluminium Al	Antimony Sb	Argon As
Arsenic As	Batrium Ba	Beryllium Be
Bismuth Bi	Boron B	Bromine Br
Cadmium Cd	Calcium Ca	Carbon C
Chlorine Cl	Chromium Cr	Cobalt Co
Copper Cu	Fluorine F	Gold Au
Helium He	Hydrogen H	Iodine I
Iridium Ir	Iron Fe	Lead Pb
Lithium Li	Magnesium Mg	Manganese Mn
Mercury Hg	Neon Ne	Nickel Ni
Nitrogen N	Oxygen O	Phosphorus P
Platinum Pt	Potassium K	Radium Ra
Silicon Si	Silver Ag	Sodium Na
Sulphur S	Tin Sn	Titanium Ti
Tungsten W	Uranium U	Vanadium V
Xenon Xe	Zinc Zn	Zirconium Zr

Some Radicals and Functional Groups :

Inorganic :

Aluminate AlO_3	Amino / Amido Group NH	Ammonium NH_4
Azide N_3	Bicarbonate HCO_3	Tetraborate B_4O_7
Bromide Br	Carbide C	Carbonate CO_3
Chlorate ClO_3	Chloride CI	Chromate CrO_4
Di/Bi Chromate Cr_2O_7	Dio/Peroxide O_2	Dithionite (hydrosulphite) S_2O_4
Fluoride F	Hydrosulphide HS	Hydroxxide OH
Hypochlorite OCl	Iodide I	Nitrate NO_3
Nitrite NO_2	Nitrosyl ON	Oxide O
Perborate BO_3	Permanganate MnO_4	Phosphate PO_4
Ortho Silicate SiO_4	Disulphide S_2	Thiocyanate SCN
Metasilicate SiO_2	Sulphuryl SO_2	Thiosulphate SO_3
Sulphate SO_4	Penta Sulphdie S_5	Titanate TiO_3
Silica SiO_2	Sulphide S	Sulphite SO_3
Zeolite $AlSi_2O_6$		

Organic

Acetyl CH_3CO	Acetate CH_3COO
Acid helide RCOX	Acyl RCO
Alkane C_nH_{2n+2}	Alkene C_nH_{2n}
Alkyne C_nH_{2n-2}	Alkyl C_nH_{2n+1}
Alkoxy RO	Allyl CH_2CHCH
Amide $CONH_2$	Amino NH_2
Amyl (Pentyl) C_5H_{11}	Anilino C_6H_5NH
Aryl C_6H_5	Benzoate C_6H_5COO
Benzoyl C_6H_5CO	Benzyl $C_6H_6CH_2$
Benzylidene C_6H_5CH	Benzylidyne C_6H_5C
Boranes BnHn+$_2$	Bromide BR
Butyl C_4H_2	Butyryl $CH_3\ (CH_2)_2CO$
Carbomoyl NH_2CO	Carbonyl CO
Carboyxl COOH	Cyanate CNO
Cyanide CN	Cyclamate $C_6H_{11}NHSO_8$
Ethoxy C_2H_5O	Ethyl C_2H_5
Glyceryl $CH_2\ (CH)\ CH_3$	Glycly NH_2CH_2CO
Hexyl C_6H_{13}	Hydrazo HNNH
Hydroxyl OH	Isocyanate NCO
Ketenes RCCO	Ketones RR_1CO
Lauroyl $CH_3\ (CH_2)\ CO_{10}$	Malonul $OCCH_2CO$
Mesyl CH_3SO_2	Methoxy CH_3O
Methyl CH_3	Methylol $HOCH_2$
Naphthoyl $C_{10}H_7CO$	Nephthyl $C_{10}H_7$
Nitro O_2N	Nitroso ON
Octyl C_8H_{17}	Oleoyl $C_{17}H_{33}CO$
Palmitoyl $C_{15}H_{31}CO$	Phenyl C_6H_5
Phenylene C_6H_4	Propyl C_3H_7

Sterate $C_{18}H_{35}O_2$	Stearoyl CH_3 $(CH_2)_{16}$ CO
Sulpho $HOSO_2$	Sulphones RSO_2R^1
Sulphonyl SO	Thio ethers RSR^1
Thiols RSH	Toluoyl $CH_3C_6H_4CO$
Tolyl $CH_3C_6H_4$	Uranyl UO_2
Ureido NH_2CONH	Ureylene NHCONH
Vanadyl VO_2	Vinyl CH_2CH
Vinylene CHCH	Vinylidene CH_2CH
Xylyl $CH_3C_6H_4CH_2$	Xylylene $H_2CC_5H_4CH_2$
Zirconyl Zro	

Table – 2 : Branches of Chemistry

Chemistry is the study of the composition and behaviour of substances, and of their effects upon one another. The main branches are inorganic, organic and physical chemistry.

Inorganic and Organic Chemistry is the study of the elements and their components. It includes the study of elemental carbon, its oxides, metal carbonates sulphides, while all other carbon compounds belong to the study of organic chemistry. Some other branches are as under-

Analytical Chemistry is the study of the process of determining the composition of a substance viz. calorimetric, gravimetric, qualitative, quantitative, spectrographic and volumetric. -

Physical Chemistry is the study of the physical changes associated with chemical reactions and the dependence of physical properties on chemical composition.

Cryochemistry or cryogenics is the study of materials and phenomena at temperature close to absolute zero.

Electrochemistry is the study of the processes involved in the inter conversion of electrical energy and chemical energy.

Radiochemistry is the study and application of chemical techniques to the purification of radioactive materials and the formation of compounds containing radioactive elements.

Thermochemistry is the branch of physical chemistry dealing with the quantities of heat absorbed or evolved during chemical reactions.

Photochemistry is the branch of physical chemistry concerned with the effects of radiation on chemical reactions.

Cytochemistry is the chemistry of living cells.

Stereochemistry is the chemistry involving consideration of the arrangement in space of the atoms in a molecule. It sees possibilities of stereoisomerism or space isomerism.

Stoich(e)iometry is the part of chemistry dealing with the determination of combining proportions or chemical equivalents.

Chemical Engineering is the design, operation and manufacture of plant or machinery used in industrial chemical processes.

Chemical Technology is the science of chemistry which studies methods and processes for transforming naturally occurring raw materials into items of consumption and means of chemical production. Processing method denotes the group of operations to which a raw material is subjected an enroute to becoming a product. It is described, as a sequence of operations carried out in corresponding apparatus or machines. Such a sequence is known as a technological scheme of flow diagram.

Table-3 : Concise Glossary Of Chemical Terms

Acid	A compound which yields hydrogen ions in solution.
Activity	Ease of undergoing chemical change.
Alloy	Metallic solid resulting from dissolving two or more molten metals in each other, possessing properties different from any of its constituents.
Amalgam	An alloy of a metal and mercury.
Analysis	The determination of the composition of a substance; the decomposition of a substance.
Atom	The smallest quantity of an element that enters into chemical combination. It has a very small, dense nucleus, positively charged. Negative particles called electrons rotate around the nucleus.
Base	The hydroxide of a metal. An alkali.
Boiling Point	The temperature at which the pressure of the vapour of a substance equal that of its surrounding, atmosphere.
Crystals	A solid in which the particles (molecules, atoms, ions) are arranged in a definite patter in space.
Decomposition	The process of breaking down a substance into a simpler one.
Deliquescence	The absorption of water from the air by a substance to the extent that the substance is dissolved in the absorbed water.
Desiccant	Drying agent absorbs moisture from its surroundings.
Distillate	The condensed liquid obtained by a distilling process.
Electrode	The plate or terminal of an electric system.
Electrolyte	A substance which will conduct a current when melted, or in solution. A substance decomposable by an electric current.
Electron	A constituent of an atom possessing a unit negative electrical charge and having negligible mass from a chemical point of view.
Element	The simplest form of matter.
Energy	The ability to do work. All changes involve loss or gain of energy.
Equation	A concise statement of a chemical reaction using the symbols and formula of the reactants and products.
Equilibrium	Condition in which two processes proceed simultaneously in opposite Directions at the same rate.
Filtrate	The liquid obtained after filtration.
Flux	Material which permits another substance to melt more easily.
Formula	The composition of a substance indicated by symbols of each element present and subscript numbers showing the number of each type of atom involved.
Freezing Point	Temperature at which a liquid changes to a solid.
Ion	An atom which has acquired an electrical charge as a result of the

	gain or loss of electrons; a charged atom or radical.
Isotopes	Atoms of an element having the same chemical properties but differing in mass number are different isotopes of the element.
Metal	Element which readily loses electrons to form positive ions; conductor of electricity.
Metalloid	Element possessing characteristics of both metals and non-metals
Mixture	A combination of substances held together by physical rather than by chemical means.
Molecule	Smallest particle of a compound capable of having the properties of the compound.
Non-metal	Element which readily gains electrons to form negative ions; nonconductor of electricity.
pH.	Logarithm of the reciprocal of the I molar concentration of the hydrogen ion; a scale indicating the acidity of a solution; if pH is less than 7 solution is acidic, if pH is 7 solution, is neutral, if pH is greater than 7 solution is alkaline.
Physical change	An alteration of the properties of a substance without affecting the substance itself.
Precipitate	A solid which forms in and settles out from a solution.
Products	The substances formed as a result of a chemical change.
Radical	A group of elements bonded together which behave chemically as a single atom.
Radioactivity	The breakdown of the nucleus of an atom through the emission of alpha, beta and gamma rays.
Salt	Compound which ionises, but which produces neither hydrogen nor hydroxide ions in solution.
Solubility	The extent to which a solute can dissolve in a solvent; the concentration of a saturated solution of a given solute
Solution	Homogeneous, non-setting mixture of two ingredients, solute and solvent.
Solvent	The medium in which a substance is dissolved.
Stable	Relatively inert; hard to decompose.
Synthesis	The formation of a compound by combining elements or more simple compounds.
Volatile	Forms a gas with case.

Other Terms :

Absolute humidity	The amount of water vapour present in the atmosphere, defined in terms of number of kilograms (or grams) of water in one cubic metre of air. The relative humidity is usually expressed as a percentage, the ratio of the pressure of the water vapour actually present in the atmosphere to the pressure of the vapour that would be present if the vapour was saturated at the same temperature.
Activated Carbon	Charcoal treated to remove hydrocarbons and to increase its powers of absorption. Used in many processes for recovering valuable materials out of gaseous mixtures, as a deodorant, and in & as masks.
Acute Effect	Immediate effect (Acid burn, Ammonia or Chlorine inhalation)
Addition compound	A chemical compound formed by the addition of an atom to a; molecule, e.g. phosgene $Co+Cl_2 = CoCl_2$.

Aero metal	A casting alloy of AI, Zn and Cu.
Affinity	Chemical attraction, the force binding atoms together.
Alkali	A soluble hydroxide of a metal, particularly the alkali metal. Alkali metals-univalent metals lithium, sodium, potassium, rubidium, and caesium (Group IA of the periodic table). Alkaline earth metals bivalent metals beryllium, magnesium, calcium, strontium, barium and radium (Group 2A of the table).
Alcoholates	Metallic salts of alcohol, formed by replacement of hydrogen atoms in, the hydroxyl groups of the latter by metals e.g. sodium ethanolate C_2H_5ONa.
Alcohol	A class of organic compounds derived from the hydrocarbons, one or more hydrogen atoms in molecules of the latter being replaced by hydroxyl groups - e.g. ethanol C_2H_5OH
Aldehydes	A class of organic compounds of the type R.CO.H where R is an alkyl or aryl radical.
Alicylic compound	A type of organic compound that is essentially aliphatic, although it, contains a saturated ring of carbon atoms.
Aliphatic compounds	Organic compounds containing open chains of carbon atoms, in contradistinction to the closed rings of carbon atoms of the aromatic compounds.
Aromatic compounds	The original concept of aromatic compounds as derivatives of benzene has been extended to certain other organic compounds.
Alkaloids	A group of basic organic substances of plant origin, containing at least one nitrogen atom in a ring structure in the molecule. Many have important physiological actions and are used in medicine, e.g. codeine, cocaine, nicotine, quinine, morphine.
Alkanes	A homologous series of saturated' hydrocarbons having the general formula $Cn_{2n+2.}$ They are chemically inert, stable and inflammable. The first four members of the series (methane, ethane, propane, butane) are gases at ordinary temperatures, the next eleven are liquids and form the main constituents of paraffin oil, the higher members are solids.
Alkenes	Olefins, A homologous series of unsaturated hydrocarbons having .the general formula CnH_2n.
Alkynes	A homologous series of unsaturated hydrocarbons having the general formula CnH_{2n-2} and containing a triple bond between two of the carbon atoms in the molecule, e.g. acetylene.
Aklylarene	An arene (e.g. benzene) with one or more hydrogen atoms in the I molecule replaced by alkyl groups, e.g. ethylbenzene.
Amides	A group of organic compounds formed by replacing hydrogen atoms of ammonia NH_3 by radicals, e.g. acetamide CH_3CONH_2. The general formula is $RCONH_2$ where $CONH_2$ is the amide group.
Amines	Compounds formed by replacing hydrogen atoms of ammonia NH_3 by organic radicals. Classified into primary amines of the type NH_2R_1 secondary NHR_2 and tertiary NR_3.
Amorphous	Non-crystalline, having no definite ;form or shape.
Amphoteric	Chemically reacting as acidic for strong bases and as basic towards strong acids, e.g. amphoteric oxide, zinc oxide, gives rise to zinc salts of strong acids and zincates of the alkali metals.
Anhydride	The anhydride of a substance is that which when chemically

	combined with water, gives that substances. A basic anhydride is the oxide of a metal and forms a base with water (Na_2O+H_2O = 2NaOH), and acidic anhydride is the oxide of a nonmetal and forms an acid with water (SO_2+H_2O)=H_2SO_4).
Anhydrite	A naturally occurring form of calcium sulphate
Anhydrous	Without water, often applied to salts without water of crystallization.
Base metals	In contradistinction to the noble metals, metals that corrode, tarnish or oxidise on exposure to air, moisture or heat.
Binary compound	A chemical compound of two elements only. Denoted by the suffix-ide, e.g. calcium carbide CaC_2.
Boiling	Ebullition. The state of a liquid at its boiling point when the maximum vapour pressure of the liquid is equal to the external pressure to which the liquid is subject, and .the liquid is freely converted into vapour. Boiling point is the temperature at which the liquid boils freely under standard atmospheric pressure i.e. 760 mm of Hg.
Carbocyclic Compounds	A class of organic compounds containing closed rings of carbon atoms in their molecules. It includes alicyclic (e.g. cyclohexane) and aromatic (e.. benzene) compounds.
Carbohydrates	A large group of organic compounds composed of carbon, hydrogen and oxygen only with general formula C_x ($H_2O)_y$.
Carcinogen	A substance capable of producing cancer (carcinoma).
Caustic	Corrosive towards organic matter (but not applied to acids), e.g. caustic soda, caustic alkali-sodium or potassium hydroxide, caustic potash - KOH, caustic soda - NaOH.
Celluloid	A thermoplastic material made from cellulose nitrate and camphor.
Cellulose	A polysaccharide that occurs widely in nature in fibrous form as the structural tissue in the cell walls of plants.
Chemical change	A change m a substance involving an alteration in its chemical composition, due to an increase, decrease or rearrangement of atoms within its molecules.
Chemical energy	That part of the energy stored within an atom or molecule that can be released by a chemical reaction.
Chloracne	A disfiguring skin disease that is caused by certain chlorinated aromatic hydrocarbons. It can result from contact, ingestion or inhalation of the chemicals.
Chromophore	Any chemical group, such as the azo group, that causes a compound to have a distinctive colour.
Chronic Effect	Effect after prolonged exposure (poisoning due to lead, chromium, j mercury etc.)
Coalgas	Fuel gas manufactured by the destructive distillation of coal in closed iron retorts, often' supplemented with watergas or natural gas. Coal-tar is a thick black oily liquid obtained as a by-product of coal-gas manufacture. Coke is a greyish porous brittle solid i containing @ 80% carbon. Obtained 'as a residue in the manufacture of coal-gas (gas-coke), also made specially in coke ovens, in which the coal is treated at lower temperatures ;than in pas manufacture.
Corrosive Liquids	Acid, Alkalis, Ammonia liquor, iCarbamate solution, caustic solution, amines etc.
Critical pressure,	Critical pressure is the pressure of the saturated vapour of a substance

temperature and volume	at the critical temperature, above ; which a gas cannot be liquefied by pressure alone. Critical volume is 'the volume occupied by unit mass of a substance at its critical; temperature and critical pressure.
Critical Velocity	The velocity at which the flow of a liquid ceases to be streamlined and becomes turbulent.
Cryostat	A vessel in which a specified low temperature may be maintained.
Culture medium	A preparation used for growing and cultivating micro-organisms for experimental purposes.
Deliquescent	Having the property of picking up moisture from the air to such an extent as to dissolve in it, becoming liquid on exposure to air.
Density	The mass of unit volume of a substance, e.g. kg/m^3.
Derivative	A compound derived from (but not necessarily prepared from) some other compound, usually retaining the general structure of the parent compound, e.g. nitrobenzene $C_6H_5NO_3$ is a derivative of benzene C_6H_6, one hydrogen atom in the molecule of the latter being replaced by a nitro group.
Detergents	Cleaning agents, products used in solution for washing or cleaning by action other than simple dissolution, usually with the aid of surface-active agents. Unlike soaps, they are effective in hard water and do not form a scum.
Diazo Compounds	Like azo compounds, diazo compounds contain two adjacent nitrogen atoms which may form and azo group, but only one is attached I to a carbon atom e.g. diazomethane CH_2=N
Diazonium Compounds	Organic compounds of the general formula RN_2X, where R is an aryl radical, RN_2 is a cation and X is an anion.
Dihydric	Containing two hydroxyl groups in a molecule, e.g. a diol.
Dyes	Coloured substances that can be fixed firmly to a material to be dyed so as to be more or less fast to water, light and soap. Types - acid Idyes, azo dyes, direct dyes, mordents, vat dyes.
Emulsion	A two-phase system in which the disperse phase consists of minute droplets of liquid
Enthalpy	Heat content H. A thermodynamic property of a substance given by H, == U+pV, where U is the internal energy, p the pressure, and V the volume.
Entropy	S. A quantity introduced in the first i place to facilitate the calculations and to give clear expression to the! results of thermodynamics.
Enzyme	A large group of proteins produced by living cells, which act as catalysts in the chemical reactions upon which life depends.
Ergonomics	The engineering aspects of the study .of the relation between human workers and their working environment.
Esters	Organic compound's corresponding to inorganic salts, derived by replacing hydrogen of an acid by an organic radical or group e.g. ethyl acetate $CH_3COOC_2H_5$ is the ethyl ester of acetic acid CH_2COOH.
Ethers	A group of organic compounds with the general formula R-O-R' formed by the condensation of two alcohol molecules.
Explosion	A violent and rapid increase of pressure in a confined space. It may be caused by an external source of; energy (heat) or by an internal exothermic reaction in which: relatively large volumes of gases are

	produced.
Explosives	Substances that undergo a rapid chemical change with production of gas on being, heated or struck
Fatigue of Metals	The deterioration of metals owing to repeated stresses above a certain critical value, it is accompanied by changes in the crystalline structure of the metal.
Fertilisers	Materials put into 'the soil to; provide compounds of elements essential to plant life more I particularly nitrogen, phosphorus and potassium.
Fire	A chemical reaction accompanied by the evolution of heat, light and flame (i.e. a glowing mass of gas). It is generally applied to the chemical combination with oxygen 'of carbon and other elements' constituting the substance being burnt.
Flammable	Substances with flash point < 80 °FJ i Those having P.P. > 80 °F are called' combustibles.
Flash Point	The lowest temperature at which a I substance gives off sufficient inflammable vapour to produce a momentary flash when a small flame is applied.
Flue Gas	The gaseous products of combustion from a boiler furnace consisting predo-minantly of CO_2, CO, O_2, N_2 and steam. Analysis of the flue ~ gases is used to check the efficiency of the furnace.
Fluid	A substance that takes the shape of the shape of the vessel containing it, a liquid or gas.
Fuel	A substance used for producing heat energy, either by means or the release of its chemical energy by combustion or its nuclear energy by nuclear fission.
Fungicide	A substance capable of destroying I harmful fungi, such as moulds and mildews.
Gas	A substance whose physical state (the gaseous state) is such that it always occupies the whole of the ; space in which it is contained.
Gas Mask	Respirator a device for protecting the face and breathing organs against poisonous gases.
Germicide	A substance capable of destroying bacteria.
Halide	A binary compound of one of the halogen elements (fluorine, chlorine, bromine or iodine), a salt of the hydride of one of these elements.
Heat	Energy possessed by a substance in the form of kinetic energy of atomic or molecular translation, rotation or vibration. The heat contained by a body is the product of its mass, temperature and specific heat capacity. It is expressed in joules, calories or B.Th. U. Heat is transmitted by conduction,; convection and radiation. Its physical effects are rise in temperature, change of state from solid to liquid (melting), solid to gas (sublimation), liquid to gas (evaporation), boiling, expansion and electrical effects.
Heat exchanger	Any device that transfers heat from one. fluid to another without allowing the fluids to come into contact with each other.
Heat of reaction	The quantity of heat given out (exothermic) or absorbed in (endothermic) a chemical reaction usually per mole of reacting substances.

Herbicides	Substances that kill plants or inhibit their growth. Selective herbicides affect only particular plant types, making it possible to attack weed growing among cultivated plants.
Heterocyclic compounds	Organic compounds containing e compounds ring structure of atoms in the molecule, the ring including atoms of elements other than carbon e.g. C_5H_5N.
Homocyclic compounds	Organic compounds the molecules compounds of which contain a ring structure of atoms of the same kind (usually carbon), e.g. benzene C_6H_6.
Homologous Series	A series of chemical compounds of uniform chemical type, showing a regular gradation in physical [properties and represented by a general molecular formula, the! molecule of each member of the series differing from the preceding one by a definite constant group of atoms, e.g. the alkanes. Members of the same homologous series are called homologous, e.g. methane CH_4, and ethane C_2H_6.
Hydrocarbons	Organic compounds that contain only carbon and hydrogen. They are classified as either aliphatic or aromatic compounds (or a combination of both). Hydrocarbons may be either saturated or unsaturated compounds.
Imide	Imido compound , a compound derived from ammonia, containing the imido group. NH, in which the two hydrogen atoms of ammonia are replaced by non acidic organic radicals.
Inert or noble gases	Rare gases, helium, neon, argon, gases krypton, xenon, radon. They are all chemically inactive, though some compounds have been reported.
Insecticide	A substance used for killing insect pests.
Isomerism	The existence of two or more chemical compounds with the same molecular formula but having different properties owing to a different arrangement of atoms within the molecule, e.g. ammonium cyanate NH_4CNO and urea $CO(NH_2)_2$ are isomers.
Latent heat	The quantity of heat absorbed or released in an isothermal transformation of phase.
Liquid	A state of matter intermediate between a solid and a gas, in which the molecules are relatively free to move with respect to each other but are restricted by cohesive I forces to the extent that the liquid maintains a fixed volume. Liquids assume the shape of the vessel containing them, but are only slightly compressible.
Local effect	Effect confined to affected part (chemical burn, dermatitis)
Malleability	The ability to be hammered out into thin sheets.
Matter	A specialised form of energy that has the attributes of mass and extension in space and time.
Melting point	The constant temperature at which the solid and liquid phase of a substance are in equilibrium at a given pressure. Melting points are normally quoted for standard atmospheric pressure.
Monomer	A chemical compound consisting of single molecules, as opposed to a polymer, the molecules of which are built up by the repeated union of monomer molecules.
Noble metals	Metals such as silver, gold and platinum, that do not corrode or tarnish in air or water and are not easily attacked by acids.

Pesticides	Substances that kill pests. They include insecticides.
Petrochemicals	Chemical substances derived from petroleum (or natural gas).
Petroleum	Mineral oil. A natural mixture of hydrocarbons and other organic compounds. Fractional disti-llation yields petrol, paraffin oil, lubricating oil, petrolatum and paraffin wax.
Plasticizer	(1) A non-volatile liquid added to I paints and varnishes to prevent brittleness of the dried film. (2) A liquid or solid substance added to synthetic or natural resins to modify their flow properties.
Polymerisation	The chemical union of two or more molecules of the same compound to form larger molecules, resulting in the formation of a new compound of the same imperial formula but of greater molecular weight, e.g. Paraldehyde (CH,CHO), is formed by the polymerisation of acetaldehyde CH,CHO monomer. It includes addition polymerisation, condensation polymerisation and copolymerisation. Many important products such as plastics and textile fibres consist of polymeric substance, either natural (e.g. cellulose) or synthetic (e.g. nylon).
Pressure	The force per unit area acting on a surface. Absolute pressure is the pressure measured with respect to zero pressure. Gauge pressure is the pressure measured by a gauge in excess of the pressure of atmosphere.
Reducing agent	A substance that removes oxygen from, or adds hydrogen to, another substance.
Refrigerant	A fluid used in the refrigerating cycle of a refrigerator, usually of a liquid that will vaporise at a low temperature, e.g. freon or ammonia.
Relative density	Specific gravity. The ratio of the density of solid or liquid at a specified temperature (often 20°C) to the density of water at the temperature of its maximum density (4°C).
Skin Poisons	Cause dermatitis and ulcer to skin (Chromates, Naphtha, Amines, Aniline etc.,)
Soda	Washing soda Na_2CO_3, backing soda, $NaHCO_3$, caustic soda NaOH.
Soda ash	The common name for anhydrous Na_2CO_3.
Soda lime	A solid mixture of NaOH and $Ca(OH)_2$
Specific heat capacity	Specific heat capacity divided by mass. The quantity of heat required to raise the temperature of unit mass of a substance by one degree.
Systemic effect	Effect on one complete or more than one systems, (exposure to CO, H_2S, Benzene, Aniline, Methanol etc.)
Temperature	Temperature is a measure of hotness of a body. It can be defined as a property determining the rate at which heat will be transferred to or from it. Temperature is thus a measure of the kinetic energy of the molecules, atoms or ions of which matter is composed.
Thermo-dynamics	The study of the general laws governing processes that involve heat changes and the conservation of energy.
Toxic	Poisonous, toxicology - the study of poison, toxin-poison.
Toxic dusts	Dust of asbestos, silica, coal, cotton, iron, lead, sugarcane hay can cause lung diseases.
Toxicity	Ability of a chemical to cause internal or external injury on human body.
Vapour	A substance in the gaseous state that can be liquefied by increasing the pressure without altering the temperature. A gas below its critical

	temperature.
Vapour density	A measure of the density of a gas or vapour, usually, given relative to Oxygen or hydrogen or air.
Vermicide	A substance used to kill worms.
Viscosity	The property of a fluid whereby it tends to resist relative motion within itself.
Water gas	A fuel gas obtained by the action of steam on glowing hot coke. It consists of CO and H.

Table-4 : Dangerous Properties of Some commonly used Chemicals

Sr. No.	Substance	Sp. Gravity	Vap. Density	Boiling Point °C	Melting Point °C	Flash Point °C	Explosive Limits %	TLV ppm	Solubility in Water
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Acetaldehyde CH_3CHO	0.78	1.52	21	-124	-38	4-57	100	Highly soluble
2	Acetic acid CH_3COOH	1.05	2.1	118	1.7	43	4-16	10	Highly soluble
3	Acetone CH_3COCH_3	0.79	2.0	56	-94	-18	3-13	750	Highly soluble
4	Acetylene C_2H_2	0.91	0.9	-83	Volatile	-18	3-82	-	Less Soluble
5	Acrolein CH_2CHCHO	0.84	1.9	53	-87	-26	3-82	0.1	Highly soluble
6	Acrylonitrile CH_2CHCN	0.81	1.8	77	-83	0	3-17	2	soluble
7	Allyl chloride CH_2CHCH_2CI	0.94	2.6	45	-136	-32	3-11	1	In-soluble
8	Ammonia (gas) NH_3	0.77	0.59	-33	-78	-	16-25	25	Highly soluble
9	Aniline $C_6H_5NH_2$	1.02	3.22	184	-6	70	1-3	2	Soluble
10	Benzene C_6H_6	0.88	2.8	80	5.4	-11	1.4-8	10	Less Soluble
11	Boron Trifluoride BF_3	2.99	-	-99	-127	-	-	1	Highly soluble
12	Bromine Br_2	3.1	5.5	59	-7	-	-	0.1	Less Soluble
13	Carbon disulfide CS_2	1.26	2.6	46	-112	-30	1-44	10(4)	Less Soluble
14	Carbon monoxide CO	0.81	0.97	-192	-207	Flammable	12.5-74	50(35)	Less Soluble
15	Caustic Soda NaOH	2.13	-	1390	315	-	-	0.2 mg/m3 STEL 1 (0.5)	Less Soluble
16	Chlorine Cl_2	2.48	2.49	-34	-101	-	-	1 (0.5)	Less Soluble

17	Chlorine dioxide ClO_2	3.09	2.3	9.9	-59	Explosion	-	0.1	Less Soluble Decompose
18	Chlorobenzene C_6H_5Cl	1.11	3.9	132	-56	29	1.3-7.1	75	In-soluble
19	o-Dinitobenzene $C_6H_4(NO_2)_2$	1.31	5.8	319	118	150	Explosive	0.15	Less soluble
20	Dioxane $C_4H_8O_2$	1.04	3.0	101	10	12	2-22.2	100 (25)	Highly soluble
21	Ethane C_2H_6	0.57	1.04	-89	-183	-	3-12.5	-	In-soluble
22	Ethanol C_2H_5OH	0.79	1.59	79	-114	12	3.3-19	1000	Highly soluble
23	Ethyl acetate $CH_3COOC_2H_5$	0.90	3.04	77	-84	-4.4	2-18.9	400	Less soluble
24	Ethyl amine $C_2H_5NH_2$	0.80	1.56	17	-81	-18	3.5-14	10	Highly soluble
25	Ethyl chloride C_2H_5Cl	0.92	2.2	12	-139	-50	3.6-15.4	1000	Less soluble
26	Ethylene C_2H_4	0.001	1.0	-104	-169	Flammable	2.7-36	-	Less soluble
27	Ethylene oxide $(CH_2)_2O$	0.87	1.49	11	-111	-18	3-100	-	soluble
28	Ethyl ether $C_2H_5OC_2H_5$	0.71	2.55	34	-123	45	1.85-48	400	Less soluble
29	Fluorine F_2	1.1	1.7	-188	-218	-	-	1 (0.1)	Decompose
30	Formaldehyde HCHO	0.82	1.08	-19	-92	-	7.0-73	2	Soluble
31	Formaline (37% formaldehyde, 15% methanol)	-	-	101	-	50	-	-	Soluble
32	Formic acid HCOOH	1.22	1.59	101	8.2	69	18-57	5	Highly Soluble
33	Hexane $CH_3(CH_2)_4CH_3$	0.66	2.97	68	-96	-22	1.1-7.5	50	In-soluble
34	Hydrochloric acid HCl	1.19	1.3	-85	-115	-	-	5	Soluble
35	Hydrocyanic acid HCN	0.69	0.93	26	-14	-18	6-41	10	Highly soluble
36	Hydrofluoric acid HF-	1.0	0.71	20	-83	-	-	3	Highly soluble
37	Hydroge-n H	0.09	0.069	-253	-259	-	4-75	-	Less soluble
38	Hydrogen sulphide H_2S	1.19	1.2	-60	-83	-	4.3-46	10	Highly soluble
39	Kerosene	0.81	4.5	170-300	-46	38-696	0.7-5	-	-
40	Lead Pb	11.3	-	1744	327	-	-	0.05 mg/m^3	In-soluble
41	Maleic	0.9	3.4	202	58	102	1.4-7.1	0.25	Decompose

	anhydride $(COCH)_2O$								
42	Mercury Hg	13.6	-	357	-39	-	-	0.1 (0.01) mg/m^3	In-soluble
43	Methane CH_4	0.42	0.6	-161	-183	-306 ^oF	5-15	-	Less soluble
44	Methanol CH_3OH	0.79	1.11	65	-98	12	6-36.5	200	Highly soluble
45	Methyl acetate $CH_3CO_2CH_3$	0.97	2.55	57	-99	-9	3.1-16	200	Highly soluble
46	Methyl bromide CH_3Br	1.73	3.27	4	-95	-	10-16	20 (5)	In soluble
47	Methyl chloride CH_3Cl	0.98	1.8	-24	-98	-	10.7-17.4	50	Less soluble
48	Methyl isobutyl ketone CH_3COCH_2 $CH (CH_3)_2$	0.80	3.5	117	-85	23	1.4-7.5	50	Less soluble
49	Methyl isocyanate CH_3NCO	0.92	2.0	39.1	-45	-6.6	5.3-26	0.02	Reaction
50	Methyl mercaptan CH_3SH	0.87	1.66	5.96	-121	-18	3.9-21.8	0.5	Less soluble
51	Naphthalene $C_{10}H_8$	1.15	4.42	210	80	79	0.9-5.9	10	In-soluble
52	Nickel carbonyl $Ni(CO)_4$	1.32	6	43	-25	-	2 LEL	0.05 (0.001)	Less soluble
53	Nitric acid HNO_3	1.50	-	86	-42	-	-	2	Highly soluble
54	Nitric oxide NO	1.34	1.04	-153	-164	-	-	25	Less soluble
55	Nitrobenzene $C_6H_5NO_2$	1.20	4.24	211	5	88	1.8-40	1	Less soluble
56	Nitrogen N_2	1.25	-	-196	-210	-	-	-	Less soluble
57	Nitrogen dioxide NO_2	1.49	1.59	20	-11	-	-	3	Decompose
58	Oxygen O_2	1.43	-	-183	-218	-	-	-	Soluble
59	Petroleum ether 79(Naphtha)	0.6	2.5	30-60	-73	-57	1-6	400	-
60	Phenol C_6H_5OH	1.07	3.24	181	40	79	1.5 LEL	5	Soluble
61	Phosgene $COCl_2$	1.39	3.4	8	-128	-	-	0.1	Decompose
62	Phosphine PH_3	0.75	1.2	-88	-133	in air	-	0.3	Less

						flammable			soluble
63	Phosphoric acid H_3PO_4	1.69	-	260	42	-	-	1 mg/m^3	Highly soluble
64	Phosphorous Pentachloride PCl_5	4.65	-	-	162 volatile	-	-	0.1	Decompose
65	Phosphorus (yellow) P_4	1.82	4.42	280	44	in air flammable	-	0.02	Less soluble
66	Phosphorous trichloride PCl_3	1.59	4.75	75	-112	-	-	0.2	Decompose
67	Phthalic anhydride $C_6H_4(CO)_2O$	1.53	5.10	284	-131	151	1.7-10.4	1	Less soluble
68	Picric acid $(NO_2)\,C_6H_2OH$	1.76	7.9	300 explo-sion 500	122	150	-	0.1 mg/m^3	Soluble
69	Potassium dichromate $K_2Cr_2O_7$	2.68	-	Decompose	398	-	-	-	Less soluble
70	Propane C_3H_8	0.58	1.56	-45	-187	-104	2.2-9.5	1000	In-soluble
71	Iso-Propanol $CH_3CHOHCH_3$	0.79	2.07	82	-89	12	2.3-12.7	200	Highly soluble
72	Propylene C_3H_6	0.51	1.5	-48	-185	-108	2-11.1	-	Highly soluble
73	Pyridine C_5H_5N	0.99	2.7	115	-42	20	1.8-12.4	5	Highly soluble
74	Silver nitrate $AgNO_3$	4.35	-	444 Decompose	212	-	-	-	Highly soluble
75	Sodium Na	0.97	-	892	98	in air flammable	-	-	Decompose
76	Styrene monomer $C_6H_6CHCH_2$	0.905	1	145	-31	31	1.1-6.1	50	In- soluble
77	Sulphur dioxide SO_2	1.4	2.3	-10	-76	-	-	2	Soluble
78	Sulphuric acid H_2SO_4	1.84	2.8	338	10	-	-	1 mg/m^3	Highly soluble
79	Sulphur trioxide SO_3 (oleum)	2.75	2.76	45	17	-	-	1 mg/m^3	Decompose
80	Toluene $C_6H_5CH_3$	0.87	3.1	111	-95	4.4	1.4-6.7	100	In- soluble
81	o-Toluidine $CH_3C_6H_4NH_2$	1.004	3.7	200	-16	85	-	2	Less soluble
82	Tributyl phosphate	0.97	9.2	292	-80	146	-	0.2	Soluble

	$(C_4H_9O)_3PO$								
83	Trichloro ethylene $ClCHCCl_2$	1.46	4.54	87	-73	-	-	50	Less soluble
84	Triethyl amine $(C_2H_5)_3N$	0.73	3.48	89	-115	-7	1.2-8.0	10	Soluble
85	Trinitro toluene $CH_3C_6H_2(NO_2)_3$	1.65	-	240 Explosion	81	-	Explosive	0.5 mg/m^3	In-soluble
86	Turpentine $C_{10}H_{16}$	0.87	4.6	153-175	-	35-39	0.08 LEL	100	-
87	Uranium U	19.5	-	3818	1130	-	-	0.2 mg/m^3	In-soluble
88	Vinyl chloride CH_2CHCI	0.91	2.15	-14	-154	-78	4-22	5	Less soluble
89	o-Xylene $C_6H_4(CH_3)_2$	0.90	1.1	144	-26	32	1-6	100	In-soluble
90	Zinc oxide ZnO	5.47	-	-	1975	-	-	5 mg/m^3	Less soluble

Table-5 : Rating Form for Activity Standards

A. Organisation and Administration

Sr. No.	Activity	Rating 'Excellent' when
1	Statement of Policy and Responsibilities assigned	Safety & Loss Control Policy is written and reviewed every year. Responsibility for safety and Loss prevention and accountability is clearly defined in supervisory performance evaluation.
2	Safe Operating Procedures (SOPs)	When all hazardous operations are covered by a procedure, posted at the job location, with an annual documented review to determine adequacy.
3	Employee Selection and Placement	When safety attitudes and record is taken into account while employees are considered for selection & promotion.
4	Emergency and Disaster Control	When all types of emergencies are covered with written procedures and responsibilities are clearly defined with back up provisions.
5	Direct Management Involvement	When safety & loss control problems are treated as other operational problems in staff meetings.
6	Plant Safety Rules	When plant work & safety rules are firmly enforced and updated at least annually.

B. Industrial Hazard Control :

Sr. No.	Activity	Rating 'Excellent' when
1	Housekeeping, storage of materials	When housekeeping, storage of materials etc. are

	etc.	ideally controlled.
2	Machine Guarding	When machine hazards are effectively controlled to the extent that injury is unlikely and safety of operations given prime consideration at the time of process design.
3	General Area Guarding	When the hazards are effectively controlled to the extent that injury is unlikely.
4	Maintenance of Equipment, Guards, Hand tool etc.	When a good preventive maintenance system is programmed for hazardous equipment and devices.
5	Material Handling	When adequate measures prevail to avoid conflict between workers and materials being moved.
6	Personal Protective Equipment, Adequacy and Use	When us of such equipment is recognized as an employment requirement.

C. Fire control and Industrial Hygiene

Sr. No.	Activity	Rating 'Excellent' when
1	Chemical Hazard Control	Hazard data sheets are posted and regularly updated. Additional standards when promulgated are discussed with employees involved.
2	Flammable and Explosive Materials Control.	When storage facilities comply fully with fire regulations, containers are always labeled and a strong policy exists with respect to handling, storage and use of flammable materials.
3	Ventilation- Fumes, Smoke and Dust Control	When the equipment is properly selected and maintained close to its maximum efficiency.
4	Skin Contamination Control	All workmen are informed about skin irritants. Provided with approved protective equipment or devices and regular medical checks are maintained to ensure that there is no ill effect.
5	Fire Control Measures	When a well trained fire crew is organized and trained in emergency procedures and in the use of fie fighting equipment.
6	Waste, Trash Control	When 'waste disposal hazards' are effectively controlled and Air /Water / Land Pollution potential is minimal

D. Supervisory Participating, Motivation and Training :

Sr. No.	Activity	Rating 'Excellent' when
1	Line Supervisor Safety training	When regular specialized sessions are conducted on specific problems
2	Indoctrination / Safety Induction of New Employees	When a formal indoctrination programme to orient new employees to Safety and Loss Prevention is in effect.
3	Job Hazard Analysis	When Job Hazard Analysis is performed on a regular basis and safety procedures are written and posted for all operations.

4	Training for specialized operations for trucks, grinding, press brakers, punch press, solvent handling, etc.	When regular evaluation is done (at least annually) to determine training needs.
5	Internal self inspection	When senior managers are invited in inspection programmes and follow up and the programme is measured by results i.e. reduction in accidents and cots.
6	Safety Promotion & Publicity	When special display cabinets programmes of slogans, posters, etc. regularly arranged.
7	Employer / Supervisor Safety Contact	When the supervisors regularly review job safety requirements with each worker and contact at least one employee daily to discuss the safe job performance.

E. Accident Investigation, Statistics and Reporting Procedures :

Sr. No.	Activity	Rating 'Excellent' when
1	Accident investigation by line personnel.	When every accident is investigated within 24 hours of occurrence and reports are reviewed by Dept. Manager and plant Manager.
2	Accident cause and injury location analysis & Statistics.	When accident causes & injuries are graphically illustrated to develop the trends and evaluate performance. Management is kept informed on status.
3	Investigation of property damage.	When management requires a vigorous investigation effort on all property damage incidents.
4	Proper Reporting of Accidents	In addition to reporting & investigation of all accidents, all staff is kept informed of all accident findings & recommendations for accident prevention.

Courtesy : Quantitative & Qualitative Measurement of Industrial Safety Activity, ASSE Journal 1970.

Table-6 : ILO Checklist for Good Housekeeping

How to use this Checklist:

1. Fill in the General Information Sheet by interviewing appropriate persons.
2. Define the work area to be checked. In the case of a small enterprise the whole production area can be checked. In the case of a larger enterprise, particular workplaces can be defined for separate checking.
3 Go through the items and determine which measure should be taken according to the following procedure :

    (a) If the measure is not needed (meaning the improvement need not be considered because it is already available or not applicable), put a check in the box under NOT NEEDED.

(b) If the measure is "needed" (meaning the improvement is necessary), put a check in the box under NEEDED. If the .measure has already been taken but needs further improvement, this box (NEEDED) should also be checked.

(c) If the measure is needed and is urgently important, check the space under HIGH PRIORITY.

(d) The space under REMARKS should be used to note down any information or comments related to the measure in question. Comments about the nature of the improvements needed or the particular work sites requiring such improvements should be given. If the measure has already been successfully applied, it may be cited as a good example.

4. Before finishing, make sure that :

(a) for all measures listed, either NOT NEEDED or NEEDED is checked.

(b) for some of the items rated as NEEDED HIGH PRIORITY is checked.

General Information Sheet

1. Name and address of enterprise : ____
____

2. Main products : ____

3. Number of employees
Office : ________________ (male : __________________ female : __________________)
Production : _____________ (male : __________________ female : __________________)
Total : __________________ (male : __________________ female : __________________)

4. Work Schedule

		No. of Employees	Timings
A.	Office :	______	From __________ To ___________
B.	Production		
	Day shift:	______	From __________ To ___________
	Afternoon shift:	______	From __________ To ___________
	Night shift:	______	From __________ To ___________

5. Break periods for production workers.:
A. Morning Break : _____ minutes
B. Lunch Break : _____ minutes
C. Afternoon Break: _____ minutes

Name of Checker : ______________________________ Date : __________________

Make four columns : (1) Not needed. (2) Needed. (3) High Priority (4) Remark, against each of the following items and write your finding against each of them.

Premises and Facilities :

These items concern the factory building itself: its floors and exits, general lighting, ventilation, and available facilities.

Floors and Exits:

1. Provide at least two unobstructed escape exits for every floor or every big room.
2 Provide barriers (e.g. bars, covers, grills) for flooi openings and handrails for stairways.
3 Change positions of partitions or walls or raise the ceiling to provide adequate workroom space.
4 Make floor surfaces smooth and even, and eliminate places where it is necessary to step up or down or over obstacles. Provide toe guards.
5 Keep oil spills and waste water off the floor by splash guards, well sealed containers, drainage or frequent clean- up.

Lighting and General -Ventilation

6. Improve daylight conditions by properly locating windows or skylights.
7. Paint ceilings white and walls light colours and keep them clean.
8. Provide general artificial lighting adequate for the type of work done by adding light sources, installing reflectors, or repositioning existing lights.
9. Increase natural ventilation by having more openings, windows or open doorways.
10. Provide adequate numbers of ventilators, electric fans or air conditioners.
11. Insulate or screen furnaces, heated metal or other sources of heat.

Welfare Facilities :

12. Provide an adequate supply of cool, potable water in all workplaces.
13. Provide sufficient sanitary facilities close to the work area, including soap for washing and separate toilets for man and women.
14. Ensure that washing and toilet facilities are regularly cleaned and properly maintained.
15. Provide a separate, comfortable and hygienic place for meals.
16. Provide storage for clothing, bicycle or other personal belongings.
17. Provide space and supplies for games, sports or other recreational activities.

Workstations:

These items concern arrangements for individual work places, often called ergonomics.

Working Postures :

18. Change work methods so that the workers can alternate standing and sitting while at work.
19. Provide good chairs for standing workers for occasional sitting.
20. Use Jigs, lifts, levers, pulleys or other mechanical measures to avoid long-lasting unnatural working postures such as bending, twisting or scinatting.
21 Avoid bending postures for standing workers by raising the height of equipment, controls or work surfaces.
22 Avoid work requiring high hand positions for standing workers by providing foot stands or platforms.
23 Provide work tables of suitable height for seated workers so that too high or low hand positions are avoided.
24 Provide chairs or benches of correct height.
25 Provide all chairs, stools and benches with a comfortable backrest.

Workstation Arrangements:

26 Put switches, controls and materials within easy reach of workers.
27 Make different switches and controls easily distinguishable from each other by changing positions, sizes and shapes.
28 Choose tools which are easy to grip and handle.
29 Make sure that tools are maintained and repaired properly and that no worn-out tools are used.

30 Place the most important displays (signals, gauges, etc.) where they are easy to see from the normal work position.
31 Add labels or colour markings to make control positions (e.g. on, off) or displays easily recognisable, especially for emergency switches.
32 Eliminate glares which strain the workers' eyes by avoiding naked or semi-shielded lamps, highly light reflecting surfaces or too bright light from windows.
33 Provide local lighting or adjustable lamps, especially for precision work.

Specific Work Hazards :

The items below concern some common occupational injury and disease hazards. There will also be legal requirements relating to these and other hazards which should be followed.

34 Provide enough fire extinguishers within easy reach.
35 Attach proper guards to dangerous moving parts of machines and power transmission equipment.
36 Ensure that all machinery guards are securely fastened to the machine or to the floor, wall or ceiling.
37 Use safety devices which prevent operation of machines while the workers' hands are in danger.
38 Eliminate irregular or entangled or octopus wiring connections.
39 Eliminate frayed or exposed electrical wires and connections.
40 Enclose or isolate as completely as possible the source of noise.
41 Reduce noise reflection by raising the ceiling or using sound absorbing materials in walls, ceiling or machine covers.
42 Enclose or isolate dust-producing machines or sources of gases or vapours.
43 Introduce or improve local exhaust ventilation at the workplace.
44 Provide adequate numbers and appropriate types of protective goggles, face shields, masks, earplugs, safety footwear, helmets or gloves.
45 Instruct and train workers about proper use and maintenance of personal protective equipment and regularly monitor its use.
46 Use posters .and notices to inform about accident risks and health hazards.
47 Provide first aid equipment and train a qualified first-aider.

Work Organisation

These items relate to arrangements for storage, materials handling and production flow as well as the ways work is allocated and scheduled.

Work Space and Storage

48 Arrange machines, equipment, material stocks or work positions to provide sufficient space to move around.
49 Provide appropriate markings .on aisles and passageways to keep them clear for movement of people and materials.
50 Assign daily. or more frequent responsibility for clearing specific areas to specific workers.
51 Provide enough waste receptacles or containers of adequate size.
52 Provide convenient storage racks for tools, raw materials, parts and products.
53 Ensure that materials, tools, products and scrap are not kept on the floor.
54 Make sure that tools are put in a clearly marked place when not in us.

Materials Handling

55 Use specially designed pallets to hold and move raw materials, semi-finished goods and products through work areas.
56 Minimise lifting of heavy loads by using appropriate platforms, low-loading trolleys, tongs and other aids.
57 Use carts, movable racks, cranes, conveyors or other mechanical aids when moving heavy loads.
58 Train workers about proper weight lifting postures using bent knees rather than a bent back..

Work Content and Scheduling

59 Rearrange layout in the order of operations to improve production flow and inventory control and to rationalise handling.
60 Combine task or establish group work stands to reduce handling operations and machine paced or repetitive work.
61 Promote communication and feed back by ensuring that workers can see and talk with each other while working.
62 Use workers' innovative capacity by establishing suggestion schemes or quality circles.
63 Establish flexible starting and finishing times using a suitable method of record keeping.
64 Insert frequent short breaks in addition to a long break for meals.

Courtesy : International Labour Organisation.

Table-7 : Classification of Pollutants

Major Classes	Subclasses	Typical members of subclasses
Particulates	Solid, liquid.	Dust, smoke, fumes, fly ash, mist, spray.
Organic Gases	Hydrocarbons Aldehydes and Ketones Other organics	Hexane, benzene, ethylene, methane, butane, butadiene, Formaldehyde, acetone, Chlorinated hydrocarbons, alcohols.
Inorganic Gases	Oxides of carbon	Carbon monoxide, Carbon dioxide
	Oxides of sulphur	Sulphur dioxide, sulphur trioxide
	Other inorganics	Hydrogen, sulphide, hydrogen fluoride, ammonia.

Table-8 : Industrial Emissions and Control Summary

Industry or process	Source of emission	Particulate matter	Method of control
Iron and steel mills	Blast furnaces, steel-making furnaces, sintering machines	Iron oxide, dust, smoke.	Cyclones, bag-houses, electro-static precipitators, wet collectors
Grey iron foundries	Cupolas, shakeout making	Iron oxide, smoke, oil dust, metal fumes, oil grease.	Scrubbers, dry centrifuge, collectors
Non-ferrous metallurgy	Smelter and furnaces	Smoke, metal fumes, oil, grease.	Electro-static recipitators, fabric filters.

Petroleum refineries	Catalyst regenerators sludge incinerators	Catalyst dust, ash from sludge.	Cyclones, electrostatic precipitators scrubbers, bag houses.
Portland cement	Kilns, dryers, material-handling systems.	Alkali and process dust	Fabric filters electrostatic precipitators mechanical collectors.
Kraft paper mills	Recovery furnaces, line kilns, smelt tanks.	Chemical dust	Electrostatic precipitators, venture scrubbers
Acid manufacture phosphoric sulphuric	Thermal processes, rock acidulating griding.	Acid mist, dust	Electrostatic precipitators mesh, mis eliminators.
Coke manufacture	Oven operation, quenching materials handling	Coal and coke dust, coal tars.	Meticulous design, operation and maintenance.
Glass and fiberglass	Furnaces, forming and curing, handling.	Acid mist, alkaline oxides, dust, aerosols.	Fabric filters, afterburners.

Table-9 : Health Effects of Particulate Matter

Concentration $\mu g/m^3$	Accompanied by	Time	Effect
750	715 $\mu g/m^3$ SO_2	24-h average	Considerable increase in illness
300	630 $\mu g/m^3$ SO_2	24-h average	Acute worsening of chronic bronchitis.
200	250 $\mu g/m^3$ SO_2	24-h average	Increased absence of industrial workers.
100-130	120 $\mu g/m^3$ SO_2	Annual mean	Children likely to experience increases incidence of respiratory disease.
100	Sulfation rate above 30 $mg/cm^2/mo$	Annual geometric mean	Increased death rate for those over 50 likely.
80-100	Sulfation rate above 30 $mg/cm^2/mo$	2-yr. geometric mea	Increased death rate for those 50 to 69 yrs.

Table-10 : Pollutants, their TLVs and Health Effects

Name of Pollutant	TLV ppm	Health Effects	Main Source
Ammonia (colourless gas with pungent odour)	25	Irritates all parts of respiratory system. Irritates eyes severely.	Ammonia manufacturing plants. Fertiliser plants.
Sulphur dioxide (colourless gas with distinctive odour)	2	Irritates respiratory system. Causes bronchitis.	Boiler flue gas, sulphuric acid manufacturing plants, fuel burning processes, metallurgical industry
Formaldehyde	1. Ceiling 0.3 ACGIH	Irritates all parts of	Petrochemical industry.

(Colourless with Pungent odour)		respiratory systems. Irritates the eyes severely	Organic chemical manufacturing plants
Chlorine (greenish-yellow gas with irritating odour)	1 0.5 ACGIH	Seven lung irritation, irritates the eyes.	Chlorine manufacturing plants Hydrochloric acid plants.
Bromine (Colourless gas with pungent odour)	0.1	Irritates all parts of respiratory systems. Irritates the eyes severely	Petrochemical industry. Organic chemical manufacturing plants
Bromine (dark reddish brown fuming liquid)	0.1	Irritates all parts of respiratory systems. Severely irritates the eyes	Dye-stuff industry, Pharmaceutical industry.
Nitrogen dioxide (red brown gas)	3	Sever irritation of respiratory system. It's danger lies in delay before it's full effect upon lungs is felt.	Nitric acid manufacturing, Nitration processes, combustion processes.
Phosgene (colourless gas with musty smell)	0.1	Severe pulmonary oedema. There may be delay of several hours before effect develops.	Pesticide, insecticide, manufacturing plants.
Carbon monoxide (colourless, odourless gas)	50 25 ACGIH	Deprives body cells of oxygen. Causes unconsciousness. Carbon monoxide combines with haemoglobin.	Combustion processes, metallurgical industries.
Hydrogen sulphide (colourless gas with offensive odour)	10	Respiratory paralysis, causes, immediate unconscious ness. In low concentration causes irritation of all parts of respiratory system.	Petroleum refineries, dyestuff industries, viscose rayon plants.
Hydrogen cyanide (colourless gas with faint odour)	10 Ceiling 4.7 ACGIH	Prevents oxygenation of body cells, shortness of breath, paralysis.	Pesticides, insecticide industry.
Benzene (colourless volatile liquid with characteristic odour)	10 0.5 ACGIH	Causes dizziness leukaemia. In low concentration caused headache.	Petrochemical industry, organic chemical manufacturing plants.
Phenol(colourless to pink crystalline substance with distinctive odour)	5	Irritates respiratory system, affects blood, irritates eyes.	Petrochemical industrial, organic chemical manufacturing plant.
Carbon disulphide (Liquid with unpleasant	10	Produce narcotic effects nerve poison, causes	Rayon manufacturing plant, pesticide industry.

odour)		unconsciousness.	
Methyl alcohol (colourless volatile liquid)	200	Causes dizziness, stupor nerve poison.	Petrochemical industry, organic chemical manufacturing plant.
Mercury (heavy silvery liquid)	0.01 0.05 0.1 mg/m^3	High poisonous, leaves metallic taste, causes nausea.	Caustic soda manufacturing plant, pesticide industry.
Hydrogen fluoride (colourless fuming gas or liquid)	3 Ceiling 3 ACGIH	The gas irritates severely the eyes.	Phosphate fertilizer industry, fertilizer industry.
Hydrocarbons	100 to 1000	Affects central nervous system	Petrochemical industry.
Sodium hydroxide (Colourless sticks)	2 mg/m^3 Ceiling 2 mg/m^3 ACGIH	Causes severe burns	Caustic soda industry, pulp and paper, soap textiles.

Table-11 : Tolerance Limits for Effluents Discharge (See also Table – 14)
(Indian Standards for Disposal of Industrial Effluents and Sewage)

Sr. No.	Characteristics	Into Inland surface waters (IS : 2490) CHD12	Into public sewers (IS : 3306) CHD12	On land for Irrigation (IS : 3307) CHD12	Into Marine Coastal Areas (IS : 7968 CHD12)	Tolerance Limits for sewage effluents discharge into Inland surface waters (IS : 4764) CHD12
1	2	3	4	5	6	7
i	pH	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0	-
ii	Temperature ^oC	40	45	-	45	-
iii	Suspended solids mg/1, Max.	100	600[a]	-	100[b]	30
iv	Particle size of suspended solids	850 micron	-	-	Floatable 3 mm Settleable 850 micron	-
v	Biochemical Oxygen Demand for 5 days at 20^oC, mg/1, Max.	30	500[c]	500	100	20
vi	Chemical Oxygen Demand, mg/1, Max.	250	-	-	250	-
vii	Total dissolved solids (inorganic) mg/1 Max.	-	2100*	2100	-	-
viii	Oils and grease, mg/1, Max	10	100	30	20	-
ix	Phenolic compounds (as C_6H_5OH), mg/1,	1.0	5.0[d]	-	5.0	-

	Max.					
x	Amonical Nitrogen (as N), mg/1, Max	50	50	-	50	-
xi	Cyanide (as CN), mg/1, Max.	0.2	2.0	-	0.2	-
xii	Sulphides (as S), mg/1, Max.	2.0	-	-	5.0	-
xiii	Fluorides (as F) mg/1, Max.	2.0	-	-	15.0	-
xiv	Chlorides (as Cl), mg/1, Max.	-	600*	600	-	-
xv	Sulphates (as SO_4), mg/1, Max.	-	1000*	1000	-	-
xvi	Total residual chlorine, mg/1, Max.	1.0	-	-	1.0	-
xvii	Insecticides, mg/1,	Absent	-	-	-	-
xviii	Arsenic (as As),mg/1, Max.	0.2	-	-	0.2	-
xix	Cadmium (as Cd), mg/1, Max.	2.0	-	-	2.0	-
xx	Chromium (hexavalent) (as Cr), mg/1, Max.	0.1	2.0	-	1.0	-
xxi	Copper (as Cu), mg/1, Max.	3.0	3.0	-	3.0	-
xxii	Lead (as Pb), mg/1, Max.	0.1	1.0	-	1.0	-
xxiii	Mercury (as Hg), mg/1, Max.	0.01	-	-	0.01	-
xxiv	Nickel (as Ni) mg/1, Max.	5.0	2.0	-	5.0	-
xxv	Selenium (as Se), mg/1, Max.	0.05	-	-	0.05	-
xxvi	Zinc (as Zn) mg/1, Max.	5.0	15	-	5.0	-
xxvii	Boron (as B), mg/1, Max	-	2.0*	2	-	-
xxviii	Percent Sodium Max.	-	60*	60	-	-
xxix	Pesticides					
	a) Organo-phosphorous compounds (as P), mg/1, Max.	-	-	-	1.0	-
	b) Chlorinated hydrocarbons	-	-	-	0.02	-

		(as Cl), mg/1, Max.				
xxx	Radioactive materials Alpha emitters, µc/ml.max.		10^{-7}	10^{-7}	10^{-9}	10^{-8}	-
	Beta emitters µc/ml. Max.		10^{-6}	10^{-6}	10^{-6}	10^{-7}	-

a = relaxable to 750 by the local authority

b = For process waste waters

For cowling water effluent - Total suspended matter content of effluent cooling water plus 10 percent

c = Subject to relaxation on tightening by the local authority relaxable to 50 by the local authority when secondary treatment of sewage is carried out

* = These requirements shall apply when after treatment, the sewage effluent is disposed of for irrigation and on land.

Note : IS:3306, 3307 and 7968 are withdrawn. See also Sch. VI u/r 3A of the Environment (Protection) Rules 1986 for standards of discharge into inland surface water, public sewers, land for irrigation and marine coastal areas. (See Table 14 in this Chapter).

Table-12 : Minimum National Standards (MINAS) (Sch. I, Environment(P) Rules 1986)

Some major parameters of effluent are tabulated below. For full details Rule 3, Schedule-1 of the Environment (Protection) Rules 1986 should be referred. These standards should not be exceeded.

Sr. No.	Industry	pH	SS mg/1	BOD mg/1 3 days at 27°C	Oil & Grease mg/l	PM mg/m^3	Others (* Footnote at end) mg/l
1.	Caustic soda	5.5-9.0	-	-	-	-	Hg* - 0.01
2.	MMF (synthetic)	5.5-9.0	100	30	-	-	-
3.	Oil refinery	6-8.5	20	15	10	-	Ph -1 S – 0.5
4.	Sugar	-	100/30	100/30	-	-	-
5.	Thermal Power	6.5-8.5	100	-	20	See Sr. No. 25	Iron - 1 Cu – 1
6.	Cotton textile	5.5-9	100	150	10	-	Ph – 5 S – 2
7.	Woollen mills	5.5-9	100	100	10	-	Ph – 5 S – 2
8.	Dye & Dye Intermediates	6-8.5	100	-	10	-	Hg – 0.01 Ph – 1
9.	Electroplating	6-9	100	-	10	-	Total metal 10
10.	Cement - upto 200 TPD - > 200 TPD	-	-	-	-	Dust 400/ 100/ 50/ 250/ 100/ 50	-

11.	Stone crushing	-	-	-	-	0.6	See also Sr. No. 37
12.	Coke ovens	5.5-9	100	30	10	-	Ph – 5 CN – 0.2
13.	Synthetic rubber	5.5-9	-	50	10	-	COD – 250
14.	Pulp & Paper (small) See also Sr. No. 29, 53 & 54	5.5-9	100	30 (100)	-	-	Sodium absorption ratio-26
15.	Fermentation	5.5-9	100	30 mg/l 100 mg/l	-	-	-
16.	Leather	6-9	100	30 (100)	10	-	Cl – 1000 Cr – 2
17.	Fertiliser	6.5-8	100	-	10	-	Cr – 2 CN – 0.2
18.	Aluminium See also Sr. No. 36	-	-	-	-	250-150	Calcination smelting
19.	Calcium carbide	-	-	-	-	250-150	Kiln Arc furnace
20.	Carbon black	-	-	-	-	150	-
21.	Cu, Pb & Zn Smelting	-	-	-	-	150	-
22.	Nitric acid	-	-	-	-	3 Kg NOx per tonne of weak acid	
23.	Sulphuric acid	-	-	-	-	4 Kg SO_2 per tonne of Concentrated acid 50 mg/m^3 Acid Mist	
24.	Iron & Steel	See Sr. No. 30	-	-	-	150 - 3 Kg. – CO per tonne of coke produced.	
25.	Thermal Power See Sr. No. 5 & 33 also	See Sr. No. 5	-	-	-	150 350	For $\geq$ 210 MW For < 210 MW
26.	Natural rubber See Sr. No. 58	6-9	100	50	10	-	COD 250 DS 2100
27.	Asbestos	-	-	-	-	0.2 fibre / cc pure asbestos	-
28	Chlor-alkali (Caustic soda)	-	-	-	-	0.2 15 35	As Hg As Cl As HCl Vapour
29	Pulp & Paper (large) See Sr. No. 14, 53 & 54	-	-	-	-	250	H_2S 10
30	Iron & Steel (integrated plant)	6-8.5	100	30	10	50/150	COD 250

	See also Sr. No. 24						
31	Reheating (Reverberatory) furnaces	-	-	-	-	150 450	Sensitive area other area
32	Foundries	-	-	-	-	450 melting rate < 3 T/h 150 melting rate > 3 T/h 150 Arc or Induction furnaces	
33	Thermal Power See Also Sr. No. 5 & 25	Stack height limits (minimum) : For > 500 MW 275 mt 200 to 500 MW 220 mt For < 200 MW $H = 14 (Q)^{0.3}$ where $Q = SO_2$ emission rate in Kg/h and H = stack height in mt For steam generation capacity 2T / h to more than 30 T/h, stack height may be from 9 to 30 mt as specified.					
34	Small Boilers	For < 2 T / h capacity, $1600\ mg/m^3$ PM For 2 to 15 T / h capacity, $1200\ mg/m^3$ PM For > 15 T/h capacity. $150\ mg/m^3$ PM					
35	Oil Refineries (SO_2)	For Distillation 0.25 kg/T of feed SO_2 emission For Catalytic Cracker 2.5 kg/ T of feed For Sulphur Recovery unit 120 kg/ T of Sulphur in feed					
36	Aluminium plants	-	-	-	-	150/250	CO 1% max
37	Stone crushing	-	-	-	-	600	-
38	Petrochemicals	6.5-8.5	1000	50	-	-	COD 250 Phenol – 5 S, CN 0.2 F 15
39	Pharmaceutical (See Sr. No. 73)	5.5-9	100	30	10	-	Hg 0.10 Cr 0.1 CN 0.1 S 2 P 5
40	Pesticides & Formulation (See Sr. No. 71)	6.5-8.5	100	30	10	-	Hg 0.01 Ph 1.0 P 5.0 CN 0.2 As 0.2 & many other
41	Tannery (See Sr. No. 57)	6.5-9	600	-	-	-	-
42	Paint	6-8.5	100	50	10	-	Ph. 1 Pb 0.1 Cr 2.0 Total metals 7
43	Inorganic chemical	6-8.5	30	-	10	-	Pb 0.1 Hg 0.01

							CN 0.2
44	Bullion refining	6.5-8.5	100	-	10	-	CN 0.2 N 10 As 0.1 Cd 0.2
45	Dye & Dye intermediate	6-8.5	100	100	10	-	Colour Hazen unit 400 Ph 1 Pb 0.1
46	Noise for Automobiles	/for three wheelers 80 dB, Car 82 dB, others 85 to 91 dB					
47	Noise for Domestic & Construction equip	AC (upto 1.5 T) 68 dB, Air Cooler 60 dB, Refrigeration 46 dB, Construction equipm 75 dB					
48	Glass industry	6.5-8.5	100	-	10	0.8 kg/T of product drawn P 50 mg/m^3 Lead 20 mg/m^3	
49	Line kiln	For capacity 5 to 40 T / day – 500 PM For capacity > 40 T – 150 PM, stack H = 14 $(Q)^{0.3}$					
50	Slaughter house, Meat & Sea Food industry	-	50 & 100	30, 100, 500	10	-	-
51	Food & Fruit processing	6.5-8.5	100 & 50	30, 200	10	-	-
52	Jute processing	5.5-9.0	100	30	10	Water consumption 1.6 m^3/ T of product produced 1	
53	Large Pupl & Paper, Newsprint, Rayon See Sr. No. 14, 29 & 54	7-8.5	50	30	TOCL 2 kg/ T of product COD 350 Total waste water discharge 150 to 200 m^3/ T of paper produced		
54	Small Pulp & Paper (upto 24000 T /year) See No. 14, 29, 53	Total waste water discharge (A) for Agrobased plant 200 m^3 of T of paper produced (B) for Waste paper based 75m^3 of T of paper produced					
55	CETP (common effluent treatment plant)	5.5-9	30, 100	-	10-20	Temp < 40oC Pesticides - Nil And many other	Ph 5, CN 2 F 15
56	Dairy	6.5-8.5	150	100	10	Waste water generation	3 m^3/KL of milk
57	Tanaries See Sr. No. 41	6.5-9.0	100	100	10	Waste water 28 m^3/T	S 1 C r 2

58	Natural Rubber See Sr. No. 26	6-8	100	501	10	-	COD 250 S 2 TDS 2100
59	Bagasse fired Boilers	PM for – (a) Step grate (b) Pulsating grate (c) Spreader stroker				 250 500 800	CO_2 12%
60	Man-Made Fibre Ind	5.5-9	100	30	-	-	Zn 1
61	Ceramic industry	-	-	-	-	150	F 10 Cl 100
62	Viscose Filament	5.5-9	100	30	-	-	Zn 5
63	Starch / Maize	6.5-8.5	150	100	-	Waste water $8m^3/T$ product discharge	
64	Hard Coke oven	-	-	-	-	150, 350	CO_2, 6%
65	Briquette industry (Coal)	(a) Capacity < 10 T (b) Capacity $\geq$ 10 T				350 150	CO_2, 6%
66	Soft coke	6.5-8.5	150	100	20	Waste weir COD 200mg/I discharge $2m^3/T$ Product	
67	Edible oil & Vanaspati industry	6.5-8.5	-	100	10	-	Ph 5 S 2 N 10 Cr 0.1
68	Organic chemicals	6.5-8.5	100	100	10	Waste water COD 200mg/ I discharge 2 M^3/T Product	
69	Flour mills	6.5-8.5	-	100	10	-	Ph 5 S 2 N 10 Cr 0.1
70	Boilers	6.5-8.5	100	100	10	Waste water discharge $2m^3$/ T wheat processed	
71	Pesticide (See Sr. No. 40)	For steam generation capacity Upto 2 T / h 2 to < 10 T /h 10 to < 15 T /h 15 & > above				 12000 800 600 150	CO_2 12%
72	Oil drilling & Gas extraction	6.5-8.5	100	100	10	-	Hg 0.01 Z 1 Ph 1 DDT 10
73	Pharmaceutical (Bulk Drugs) (See Sr. No. 39)	5.5 – 9.0	100	30	10	-	Cr 0.1 CN 0.005
74	Brick kilns	6.5 – 8.5	100	100	10	-	Hg 0.01 As 0.2 S 2 P 5
75	Soda ash (inland)	6.5 - 9	100	-	10	-	Temp $\leq$ 45°C

76	Cupola Furnace	SO_2 emission			300	CO_2, 12%
77	Motor Petrol	Benezene 5%, Pb 0.15 (low leaded) Test Method IS 1448 Pb 0.013 (unleaded), S 0.1% (unleaded), 0.2% (leaded) Phos 15				
78	Diesel Fuel	S 0.5% (Test Method IS : 1448)				

* Footnote :

SS = Suspended Solids
PM = Particulate Matter
P = Phosphate
CN = Cyanides
Cu = Copper
Pb = Lead
Zn = Zinc

DS = Dissolved Solids
Ph = Phenol
Hg = Mercury
Cl = Chlorides
Cr = Chromium
N = Nitrates
Cd = Cadmium

BOD = Biological Oxygen Demand
COD = Chemical Oxygen Demand
S = Sulphide
F = Fluorides
As = Arsenic
TOCL = Total organic chloride
Phos = Phosphorous

\# Sr. No. 79 to 98 have been added by subsequent amendment. For the latest MINAS, the last amended law should be referred.

Table-13 : National Ambient Air Quality Standards (NAAQS)
Schedule VII Rule (3B) of the Environment (Protection) Rules

Pollutant	**Time Weighted Average**	**Concentration in Ambient Act, μg/m^3**			
		Industrial area	**Residential, Rural & other area**	**Sensitive Area**	**Method of Measurement,**
1	**2**	**3**	**4**	**5**	**6**
Sulphur Dioxide (SO_2)	Annual average 24 hours	80 120	60 80	15 30	- Improved west and Gaeke method - Ultraviolet fluorescence
Oxide of Nitrogen as NO2	Annual average * 24 hours **	80 120	60 80	15 30	- Jacab & Hochheiser modified (Na-Arsenite) Method Gas phase chemiluminescence.
Suspended particulate matter (SPM)	Annual average * 24 hours **	360 500	140 200	70 100	-High volume sampling -[Average flow rate not less than 1.1 m^3/ minute]
Respirable particulate matter less than 10 μm) (RPM)	Annual average * 24 hours **	120 150	60 100	50 75	Respirable particulate matter (size sampler)
Lead (Pb)	Annual average * 24 hours **	1.0 1.5	0.75 1.00	0.50 0.75	- AAS method after sampling using EPM 2000 or equivalent filter paper.
Carbon monoxide	8 hours** 1 hour	5 mg/mt^3 10 mg/mt^3	2 mg/mt^3 4 mg/mt^3	1 mg/mt^3 2 mg/mt^3	-Nondisbersive infrared specroscopy.

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/ 8 hourly values shall be met 98% of the time in a year, 2% of time, it may exceed but not on two consecutive days.

Note ; 1. National Ambient Air Quality Standard : the levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.

2. Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it shall be considered adequate, reason to institute regular / continuous monitoring and further investigations.

Table-14 : General Standards for Discharge of Pollutants

Schedule VI u /r 3A of the Environement (P) Rules is reproduced below for some of the standars only.

See also guidelines of Annex. I & II therein.

Part A : Effluents, limit mg/lit for inland surface water	
Colour & odour – Minimum	pH – 5.5 to 9.0
Suspended solids – 100	Temp - <5°C above the receiving water temp.
Size of suspended solids – to pass 850 micron IS sieve	Oil & grease – 10
Chlorine – 1.0	Free Ammonia – 5
Ammonical nitrogen – 50	BOD (3 days at 27°C) 30
Kjeldahl nitrogen – 100	COD – 250
Arsenic – 0.2	Mercury – 0.01
Lead – 0.1	Cadmium – 3.0
Total chromium – 2.0	Zinc – 5.0
Selenium – 0.05	Nickel – 3.0
Cyanide – 0.2	Fluoride – 2.0
Phosphates – 5.0	Sulphide – 2.0
Phenolic compounds – 1.0	Manganese – 2.0
Iron – 3.0	Vanadium – 0.2
Nitrate Nitrogen – 10 Bio- assay test – 90% survival of fish after 96 hrs. in 100% effluent.	Radioactive materials : (a) Alpha emitters 10^{-7} micro curie / ml (b) Beta emitters – 10^{-6} micro curie/ml

Part D : General Emission standards in mg/Nm^3	
Particulate matter (PM) – 150	Total fluoride – 25
Asbestos – 4 fibres /cc and dust < 2mg/ Nm^3	Mercury – 0.2 Chlorine – 15
HCl vapour & mist – 35	H_2SO_4 mist - 50
CO – 1% max. (V/V)	Lead – 10

Stack Height limit in Mt.		
Power	- 500 MW & more	-275
Generation	- 200 to 500 MW	-220
Capacity	- less than 200 MW	- $H = 14 (Q)^{0.3}$
H = Height in mt.	Q = SO_2 emission rate kg/ hr.	

Table-15 : Permissible levels (TLV & STEL) of certain Chemicals in Work Environment

(2nd Schedule under the Factories Act, as revised by Notification dated 22-7-1988)

	Substance	Permissible exposure			
		Time Weighted Average (TWA) concentration (8 hrs)		Short – term exposure limit (STEL) (15 Min)	
		Ppm	Mg/ m3	Ppm	Mg/m3
1	Acetaldehyde	100	180	150	270
2	Acetic acid	10	25	15	37
3	Acetone	750	1780	1000	2375
4	Acrolein	0.1	0.25	0.3	0.8
5	Acrylonitirle Skin (S.C.)	2	4.5	-	-
6	Aldrin – Skin	-	0.25	-	-
7	Allyl Chloride	1	3	3	6
8	Ammonia	25	18	35	27
9	Aniline – Skin	2	10	-	-
10	Anisidine (o.pl. – isomers) – skin	0.1	0.5	-	-
11	Arsenic & soluble compounds (as As)	-	0.2	-	-
12	Benzene (S.C.)	10	30	-	-
13	Beryllium & compounds (as Be) (S.C.)	-	0.00 2	-	-
14	Boron trifluoride – C	1	3	-	-
15	Bromine	0.1	0.7	0.3	2
16	Butane	800	1900	-	-
17	2- Butanone (Methylethyl Ketone- MEK)	200	590	300	885
18	n- Butyl acetate	150	710	200	950
19	n- Butyl alcohol- Skin – C	50	150	-	-
20	Sec/ Tert. Butyl acetate	200	950	-	-
21	Butyl mercapatan	0.5	1.5	-	-
22	Cadmium Dusts and salt (as Cd)	-	0.05	-	-
23	Calcium oxide	-	2	-	-
24	Carbaryl (Sevin)	-	5	-	-
25	Carbofuran (Furadan)	-	0.1	-	-
26	Carbon disulphide- Skin	10	30	-	-
27	Carbon Monoxide	50	55	400	440
28	Carbon tetrachloride Skin	5	30	-	-

	(S.C.)				
29	Chlordane - Skin	-	0.5	-	2
30	Chlorine	1	3	3	9
31	Chlorobenzene (Monochloro benzene)	75	350	-	-
32	Chloroform (SC)	10	560	-	-
33	Bis (Chloromethyl) ether (H.C.)	0.001	0.005	-	-
34	Chromic acid and Chromates (as Cr)	-	0.05	-	-
35	Chromous salts (as Cr)	-	0.5	-	-
36	Copper Fume	-	0.2	-	-
37	Cotton dust, raw	-	0.2 **	-	-
38	Cresol, all isomers – Skin	5	22	-	-
39	Cyanide (as CN) – Skin	-	5	-	-
40	Cyanogen	10	10	-	-
41	DDT (Dichloro Diphhenyl Trichloroethane)	-	1	-	-
42	Demeton – skin	0.01	0.1	-	-
43	Diazinon-Skin	-	0.1	-	-
44	Dibutylphth alate	-	5	-	-
45	Dichlorvos (DDVP) Skin	0.1	1	-	-
46	Dieldrin – Skin	-	0.25	-	-
47	Dinitrobenzene (all isomers) Skin	0.15	1	-	-
48	Dinitrotoluene-Skin	-	1.5	-	-
49	Diphenyl (Biphenyl)	0.2	1.5	-	-
50	Endosulfan (Thiodan) skin	-	0.1	-	-
51	Endrin – Skin	-	0.1	-	-
52	Ethylacetate	400	1400	-	-
53	Ethyl alcohol	100 0	1900	-	-
54	Ethanolamine	10	18	-	-
55	Fluorides (as F)	-	2.5	-	-
56	Fluorine	1	2	2	4
57	Formaldehyde (S.C.)	1.0	1.5	2	3
58	Formic acid	5	9	-	-

59	Gasoline	300	900	500	1500
60	Hydrazine – Skin (S.C.)	0.1	0.1	-	-
61	Hydrogen chloride – C	5	7	-	-
62	Hydrogen cyanide – Skin – C	10	10	-	-
63	Hydrogen fluoride (as F) – C	3	2.5	-	-
64	Hydrogen peroxide	1	1.5	-	-
65	Hydrogen sulphide	10	14	15	21
66	Iodine - C	0.1	1	-	-
67	Iron Oxide Fume (Fe_2O_3) (as Fe)	-	5	-	-
68	Isoamyl acetate	100	525	-	-
69	Isoamyl alcohol	100	360	125	450
70	Isobutyl alcohol	50	150	-	-
71	Lead, inorg. Dusts and fumes (as Pb)	-	0.15	-	-
72	Lindane – Skin	-	0.5	-	-
73	Malathion- Skin	-	10	-	-
74	Manganese (as Mn) dust and compounds (C)	-	5	-	-
75	Mangense fume (as Mn)	-	1	-	3
76	Mercury (as Hg) Skin	-	-	-	-
	Alkyl compounds	-	0.01	-	0.03
	All forms except alkyl vapour	-	0.05	-	-
	Aryl and inorganic compounds	-	0.1	-	-
77	Methyl alcohol (Methanol) skin	200	260	250	310
78	Methyl cellosolve (2 Methoxyetha nol) skin	5	16	-	-
79	Methyl isobutyl ketone	50	205	75	300
80	Methyl isocyanate- Skin	0.02	0.05	-	-
81	Napthalene	10	50	15	75

82	Nickel carbonyl (as Ni)	0.05	0.35	-	-
83	Nitric acid	2	5	4	10
84	Nitric oxide	25	30	-	-
85	Nitrobenzene Skin	1	5	-	-
86	Nitrogen dioxide	3	6	5	10
87	Oil mist mineral	-	5	-	10
88	Ozone	0.1	0.2	0.3	0.6
89	Parathion – Skin	-	0.1	-	-
90	Phenol – Skin	5	19	-	-
91	Phorate (Thimet) Skin	-	0.05	-	0.2
92	Phosgene (Carbonyl chloride)	0.1	0.4	-	-
93	Phosphine	0.3	0.4	1	1
94	Phosphoric acid	-	1	-	3
95	Phosphorus (yellow)	-	0.1	-	-
96	Phosphorous pentachloride	0.1	1	-	-
97	Phosphorous trichloride	0.2	1.5	0.5	3
98	Picric acid-Skin	-	0.1	-	0.3
99	Pyridine	5	15	-	-
100	Silane (Silicon tetrahydride)	5	7	-	-
101	Sodium hydroxide C	-	2	-	-
102	Styrene monomer (Phenyl-ethylene)	50	215	100	425
103	Sulphur dioxide	2	5	5	10
104	Sulphur hexafluoride	1000	6000	-	-
105	Sulphuric acid	-	1	-	-
106	Tetraethyl lead (as Pb) Skin	-	0.1	-	-
107	Toluene (Toluol)	100	375	150	560
108	O-Toluidine Skin (SC)	2	9	-	-
109	Tributyl phosphate	0.2	2.5	-	-
110	Trichloroethylene	50	270	200	1080
111	Uranium, Natural (as U)	-	0.2	-	0.6
112	Vinyl chloride (H.C.)	5	10	-	-
113	Welding fumes	-	5	-	-
114	Xylene (o-m-p-	100	435	150	655

	isomers)				
115	Zinc oxide	-	-	-	-
	Fume	-	5	-	10
	Dust (Total dust)	-	10	-	-
116	Zirconium compounds (As Zr)	-	5	-	10

Ppm : Parts of vapour or gas per million parts of contaminated air by volume at 25 ^{o}C and 760 toor (mm of mercury)

Mg/m^3 : milligram of substance per cubic metre of air.

$$\text{Mg/m}^3 = \frac{\text{Molecular weight}}{24.45} \times \text{ppm}$$

* Not more than 4 times a day with at least 60 min. interval between successive exposures.

** lint – free dust as measured by the vertical elutriator cotton dust sampler.

C : ceiling limit.

Skin : potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye.

C.S. : suspected human carcinogens.

H.C. : confirmed human carcinogens.

Substance	Permissible time- weighted average concentration (TWA Hours)
Silica, SiO2	
(a) Crystalline	
(i) Quartz	
(1) In terms of dust count	$\frac{10600}{\% \text{ Quartz} + 10}$ mppcm
(2) In terms of respirable dust	$\frac{10}{\% \text{ respirable Quartz}}$ mg/m^3
(3) In terms of total dust	$\frac{30}{\% \text{ Quartz} + 3}$ mg/m^3
(ii) Cristobalite	Half the limits against quartz
(iii) Tridymite	Half the limits given against quartz
(iv) Silica, fused	Same limits as for quartz
(v) Tripoli	Same limit as formula in item (2) given against quarts
(b) Amorphous	10 mg / m^3 Total dust
Silicates Asbestos (H.C.)	# 2 fibres / ml. greater than 5 µm is length and less than 3 µm in breadth.
Portland cement	10 mg/m^3 total dust, containing less than 1% quartz.
Coal Dust	2 mg/m^3 respirable dust fraction containing less

		than 5% quartz.

mmpcm – Million particles per cubic metre of air, based on impinger samples counted by light field techniques.

#As determined by the membrane filter method at 400-450 X magnification (4 mm objective) phase contrast illumination.

Respirable Dust – Fraction passing a size – selector with the following characteristics :

Aerodynamic Diameter (µm) (Unit density sphere)	**% passing selector (µm)**
2	90
2.5	75
3.5	50
5.0	25
10	0

Table-16 : Merits and Demerits of some Waste Disposal Methods.

Method	**Advantages**	**Disadvantages**
Conventional landfill	Low cost	Unsuitable for hazardous wastes
	Ease of operation	Ground and surface water pollution potential.
Secure (chemical) landfill	Availability of existing sites	Hazardous to landfill operators
	Moderate cost	Public opposition
	Relatively cost	Dewatering and/or other pre-treatment
	Waste contaminate	Unsuitable for liquids & flammable materials
	Low ground and surfaces water pollution potential	Uncertain long-term durability of lines need for perpetual care, High land consumption, High cost.
Incineration (and other treatment processes)	Detoxification	Air Pollution potential
	Volume reduction	Residues are often hazardous
	Lowland requirement	Variable performance
	Potential for energy	Requires skilled operation
	Flexibility	Auxiliary fuel sometimes required
Waste treatment (chemical, physical, biological)	Detoxification	High capital and operational costs
	Volume reduction	High sludge production need for ultimate solid disposal
	Proven technology	High land requirement
	Acceptability	Some processes solid disposal
Land application (effluents, sludge)	Moderate cost	High land requirement
	Resource recycle	Uncertain fate of some materials in soil.
	Zero stream discharge	Water pollution potential

	Land may remain in agricultural use	Limited by suitable soils, geology, site conditions, climate
Deep well injection	Moderate cost	High risk of ground water contamination
	Low land requirement	Highly dependent on favourable geology.
	No short term impacts or long term care	Discouraged by many regulatory agencies.
Ocean disposal	Moderate cost	Unacceptable by regulatory agencies.
	No onshore impacts	Marine aquatic life endangered
Resource recovery (Materials, energy)	Resource conservation	Market uncertainties
	Lower ultimate disposal requirement	Unproven technology for some wastes
	Potential economic benefits	Possible economic disadvantages recovered / recycled resources Vs other virgin sources
	Acceptable to public and regulatory agencies.	

Table-17 : Scrubbing / Neutralising / Inactivating Media

Sr. No.	Chemical	Scrubbing, Neutralising or Inactivating media	Material of Construction
Gases			
1	Phosgene $COCl_2$	Caustic Soda solution.	Water scrubber of FRP followed by Caustic scrubber of MSRL (or Caustic scrubber alone)
2	Chlorine Cl2	Caustic / lime	MSRL/PP backed by FRP.
3	Sulphur dioxide SO_2	Caustic soda solution	Polypropylene backed by FRP up to their thermal unit or SS scrubber
4	Ammonia gas NH3	Water	MS
5	Hydrochloric acid HCl	Caustic / lime	MSRL / PP backed by FRP
6	Nitrous acid fumes	Caustic / Thiosulfate solution / Urea.	FRP.
7	Hydrogen fluoride HF	Water/ Caustic	Teflon.
8	Hydrocyanic acid HCN	Water incineration	MSRL / PP backed by FRP
9	Ehtyl chloride C_2H_5Cl	Water (poor solubility)	-
10	Ethylene oxide CH_2-O-CH_2	Water spray or pond	MS Tower
11	Hydrogen sulphide H_2S	17% Monoethanol amine and 83% water or Caustic.	MSRL
12	Hydrogen H_2	Ignite, use back flame arrestor.	MS

13	Propylene $CH_2 - CH = CH_2$	- do-	
14	Ethylene $CH_2 = CH_2$	- do-	
15	Organic gases	- do -	
16	Fluoride, $SiF4$ from acidication of phosphate rock	Water spray	
Liquids (Acids)			
17	Sulphuric acid H_2SO_4	Lime / Caustic / Water	MSRL
	Hydro-chloric acid HCl	Lime / Caustic / Water	MSRL
	Nitric acid HNO_3	Lime / Caustic / Water	MSRL
(Alkalis)			
18	Sodium hydroxide NaOH	Water	MS
	Potassium Hydroxide kOH	Water	MS

Note : At appropriate places heat exchangers will be required in circulating system depending on the concentration of gases and absorbing liquor.

See part 8.1 of Chapter 18 for further selection of Material of Construction.

Table-18 : Guide for Selection of Dust Collectors

		Industry & Operations	**Particle size**		**Collector type used**
1	**Ceramics**				
	a	Raw product handling	Fine	1	Wet Collector
	b	Fettling	Fine to Medium	2	Fabric arrester
2	**Chemicals**				
	a	Material handling	Fine to medium	1	High efficiency cyclone
	b	Crushing, grinding	Fine to Coarse	2 3	Wet collector Fabric arrester
3	**Foundry**				
	a	Shake out	Fine	1	Wet Collector
	b	Sand handling	Fine to Medium	2	Wet collector
	c	Abrasive cleaning	Fine to medium	3	Fabric arrester
4	**Grain Elevator, Flour and Feed mills**				
	a	Grain Handling	Medium	1	Fabric arrester
	b	Flour dust	Medium	2	High efficiency cyclone.
	c	Feed mill	Medium	3	Fabric arrester
5	**Metal Working**				

	a	Grinding, brushing and abrasive cut off operations	Coarse	1 Low pressure cyclone 2 High efficiency cyclone
	b	Portable and Swing frame Grinder	Medium	1 High efficiency cyclone 2 Wet collector
	c	Buffing	Fine Medium Coarse	1 Cyclone 2 Wet collector
	d	Tool room	Fine	1 Cyclone 2 High efficiency cyclone 3 Wet collector 4 Fabric arrester
6	**Pharmaceutical and Food products**			
	a	Mixer, grinding weighing, blending, bagging, packing	Medium	1 High efficiency cyclone 2 Wet collector 3 Fabric arrester
	b	Coating pan	Fine to Medium	1 Wet collector 2 Fabric arrester
7	**Wood working**			
	a	Wood working machines	Fine Medium coarse	1 Low pressure cyclone 2 Fabric arrester
	b	Sanding operations	Fine	1 Low pressure cyclone 2 Fabric arrester
	C	Waste conveying systems	Fine Medium Coarse	Low pressure cyclone

Dust category :

Fine - 50 percent of dust particles are less than 5 micron size.
Medium - 50 percent of dust particles are between 5 to 15 micron size.
Coarse - 50 percent of dust particles are 15 micron on larger in size.

Table-19 : General Factors of Safety for Some Construction Materials

	Material	Steady Load	Load varying from Zero to maximum in		Suddenly Varying loads and shocks
			One Direction	Both Directions	
1	Wrought iron	4	6	8	12
2	Steel	5	6	8	12
3	Cast iron	6	10	15	20
4	Wood	8	10	15	20
5	Brick	15	20	25	30
6	Stone	15	20	25	30

Courtesy : Accident prevention manual for industrial operations, NSC, USA.

Table-20 : Load Bearing Capacity of Soils

	Natural of Soil	Safe Bearing Capacity

		Ton/ Ft^2
1	Soft clay	1
2	Fine loose and	1-2
3	Medium clay, stiff but capable of being spaded	2-4
4	Loose, medium and coarse sand, fine compact sand	1.5-4
5	Gravel, coarse sand, in natural thick beds	4-5
6	Hard clay, requiring picking for removal	4-5
7	Compact sand and gravel requiring picking of removal	4-6
8	Soft rock, disintegrated ledge, in natural ledge difficult to remove by picking	5-10
9	Hardpan, cemented sand and gravel, difficult to remove by picking.	8-10
10	Sound shale or other medium rock requiring blasting for removal	10-15
11	Solid ledge of hard rock, such as granite, trap etc.	25-100

Courtesy : Accident Prevention Manual for Industrial .Operations, NSC, USA.

Table 21 : Angle of Repose of Some Soils

Angle of repose or critical slope is the minimum angle of plane along which coarse particles in the material begin to fall due to gravity. It suggests safe stacking. –

Material	Slope Ratio Horizontal : Vertical	Angle of Response in Degree
Ashes : coal	1.0:1	45
Cinders : coal	1.0:1	45
Clay : dry : damp	1.3:1 2.0:1	38 27
Coal : broken	1.4:1	36
Earth : dry Damp	1.3:1 2.0:1	38 27
Gravel : round Angular	1.7:1 1.3:1	30 38
Rock : broken : Soft Hard	1.5:1 1.3:1	34 38
Rock : weathered : residual	1.5:1	34

Table 22 Conservation Factors :
Distance

1 inch	=	2.54 cm
1 foot	=	0.3048 mt.
1 mt	=	3.28 foot
1 km	=	0.6213 mile
1 mt	=	10^9 nanometer
1 nonometer	=	10^9 mt
1 mile	=	0.8690 nautical mile (Sea)
	=	1.6092 km

1 nautical mile	=	1.1508 mile
	=	1.8532 km
1 mt^2	=	10.7639 ft^2
1 ft^2	=	0.0929 mt^2
1 mt^3	=	35.31 ft^3
1 ft^3	=	0.0832 mt^3
1 centimeter	=	0.01 meter
	=	0.03281 feet
	=	0.3937 inches
	=	0.00001 kilometer.
	=	0.00000621 mile
	=	10000 microns

Pressure

1 atm	=	1.033 kg/cm2
	=	760mm of Hg
	=	14.696 Ibs/sq.inch (14.7)
	=	101.325 Killo Pascals
	=	0.101325 Mega Pascals
	=	29.92 inches of Hg at 0°C
	=	33.9 feet of water at 4°C
	=	10.33 meters of water
	=	1.013 bar
1 kg/cm^2	=	0.9678 atm
	=	735.5 mm of Hg
	=	0.9806 bar
	=	98.06 Killo Pascals
	=	0.098 Mega Pascals
	=	2048 lb/f^2
	=	14.22 lb/ $inch^2$
1 bar	=	0.9869 atm
	=	750mm of Hg
	=	14.502 Ibs/sq.inch '
	=	1.02Kg/ cm^2
	=	100 Killo Pascals
	=	0.1 Mega Pascals
	=	29.53 inches of Hg at 0^oC
	=	33.45 feet of water at 4°C
1 lb/ft^2	=	0.0004882 kg/cm^2
1 lb/ $inch^2$	=	0.07031 kg/cm^2
1 Pascal	=	1 $Newton/m^2$
1 Torr	=	1 mm of Hg at 0^oC

Mass

1 kg	=	2.205 lb
	=	1000 grams
1 lb	=	0.4536 kg
1 miligram	=	1000 microgram
	=	0.001 gram
1 gram	=	1000 milligram
	=	10^6 microgram
1 microgram	=	10^6 gram

	=	0.001 milligram

Volume

1 CC	=	0.06102 cu-inch
1 cu-inch	=	16.39 CC
1 cu-mt	=	35.31 cu-foot
	=	219.97 U.K. gallon
	=	264.18 U.S. gallon
	=	1000 It
1 cu – foot	=	0.02832 cu-mt
	=	6.2290 U.K. gallon
	=	7.4805 U.S. gallon
	=	28.317 Liters
1 ltr	=	0.001 cu-mt
	=	0.2642 gallon
1 gallown	=	3.785 It
1 Barrel (oil)	=	35 U.K. gallons
	=	42 U.S. gallon
	=	5.615 ft^3
	=	0.159 m^3

Area

1 cm^2	=	0.001076 ft^2
1 ft^2	=	929 cm^2
1 ft^2	=	0.0929 mt^2
1 mt^2	=	10.76 ft^2
1 km^2	=	0.3861 $mile^2$
1 $mile^2$	=	2.59 km^2
1 mt^2	=	1.196 $yard^2$
1 $yard^2$	=	0.8361 mt^2
1 acre	=	0.001563 $mile^2$
1 $mile^2$	=	640 acre
1 acre	=	0.004047 km^2
1 km^2	=	247.1 acre
1 hectare	=	0.01 km^2
1 km^2	=	100 hectare

Speed

1 cm/sec	=	1.969 ft/min
1 ft/ min	=	0.508 cm /sec
1 km / hr	=	0.6214 mile/ hr
1 mile / hr	=	1.609 km/hr

1 Mile (nautical)/ hour = 1 knot.

Temperature

1°C	=	33.8°F
1°F	=	-17.22°C
1°C	=	274.1°Kelvin
1°Kelvin	=	272.1°C

1 Centrigrade (°C) x 1.8 + 32 + Faharen height (°F)

$0^oC = 273.16^o$ Kelvin = 459.17 Rankine

Power

1 hp	=	0.7457 kw = 745.7 watts.
1 kw	=	1.341 hp
1 lb-foot /sec	=	0.3241 calorie / sec
1 Calorie / sec	=	3.085 lb- foot /sec
1 BTU / hr	=	0.01667 BTU / min
1 BTU / min	=	60 BTU / hr

Work Energy

1 BThU	=	1.055 KJ
	=	0.252 K. Cals
	=	0.0002928 KWH.
1 K. Cal	=	4.186 KJ
	=	3.968 Btu
	=	0.001162 KWH
1 K Joul	=	0.0002777 KWH
	=	0.2388 K. Cals
	=	0.9478 Btu
1 Ton of refrigeration	=	12000 BTU / HR
	=	3024 Kcal/ Hr
	=	3.516 KWH / Hr.
1 Therm	=	100,000 BTU.

Flow

1 lt / Sec	=	2.119 foot^3/mt
1 foot^3/mt	=	0.4719 lt/sec
1 lt/sec	=	951 gallon /hr
1 gallon/hr	=	0.001052 lt/sec
1 mt^3/hr	=	0.2778 lt/sec
1 lt/sec	=	3.6 mt^3/hr

Density

1 lb /ft^3	=	16.02 kg/mt^3
1 kg/mt^3	=	0.06243 lb/ft^3
1 gm/cm^3	=	0.03613 lb/inch3
1 lb/inch^3	=	27.68 gm/cm^3

Light

1 foot-candles	=	10.76 lux
1 lux	=	0.0929 foot-candles
1 meter-candles	=	1 lux

Others

1 million	=	1000000 = 10 lakhs
1 Billion	=	1000 Million = 100 crores.

Surface area and Volume

R = radius of circle, d = diameter of circle, Π = 3.1416, Circumference of circle = Πd = $2 \Pi R$, area of circle = $\Pi d^2/4 = \Pi R^2$., Volume of sphere = $\Pi d^3/6 = 4/3 \Pi R^3$.

If a altitude, b = base, Area of a triangle = ab/2.

CHAPTER – 33

History of Science and Safety Movement

Some historical part of Indian and foreign origins of the safety movement is already given in Part5 of Chapter-1, Part-1 of Chapter-7 and Part-1 of Chapter-27. Some more scientific and safety historical events are given below in a chronological order. This explains us how the scientific inventions were evolved and incidental safety concept was developed.

Vedkal	Yajurved, Rugved, Upnishads etc. Old concept of science and safety in nation. Our ancient heritage.
BC 3500	Medhatithi of Bharat discovered decimal system.
BC 3000	The Ebers Papyrys and the Edwin Smith Papyrus, the first written document on health and safety.
BC 2000	Chanakya Kautilya's Arthshastra dealing many subjects including safety. See Part-5.1 of Chapter-1.
BC 2000	Babylonian code of Hammurabi of some 280 paragraphs covering bodily injuries and workers' compensation laws.
BC 1500	Ramses III hired Physicians to care for mine and quarry workers.
BC 1000	Acharya Dhanvantari invented 'Pharmacy' and Sushrut 'surgery'. Bhrugu shilp Sahitya on many branches of Engineering.
BC 800	Bodhayan's Shalvasutra - Principle of right angle.
BC 680	Invention of 'atom' by Kanad muni.
BC 427-347	Pleto's teaching of mathematics and globe shapes of all planets.
BC 400	Hippocrates, known as the father of medicine described tetanus.
BC 384-322	Philosophy of science by Aristotle.
BC 320	Indian sword gifted to Alexander.
BC 287-212	Displacement of water, buoyancy and specific gravity by Archimedes.
BC 200	The effects of lead poisoning were described by the Greek poet and physician Nicander.
BC 100 to 2nd Century	Various Roman writers described the plague of Athens, the ill effects of their environment on mine workers and unhealthful effects of lead for water piping and wine containers.
100-178	Ptolemy who told that the Sun moves around the earth. His book, 'The Great Treatise of Astronomy'. He gave mathematical models.
650	Aryabhatttoid thatSun'shines themoon and earth rotates. This results in day and night;
Fifth Century	Aryabhatt's contribution in Mathematics. His discovery of D (22/7), sine, cosine etc.
Eight Century	Nagarjun's book 'Ras ratnakar' on Chemistry.
700-800	In Lombardy, King Rothari codified the laws in 388 chapters on principles of compensation for injury. Bhaskaracharya's 'Lilavati Ganit' i.e. Algebra and Law of Gravitation.
1456	First printing press in Germany by Gutenberg.
1473-1543	Nicolas Copernicus told that the Sun is the centre and the Earth and other planets move around it. This was told by Aryabhatta many years ago in 650. .
1473	Ulrich Ellen bag, an Austrian physician warned about hazards of metal burning.

1561	George Agricola's book described air venting in mines and use of gloves, leggings and masks.
1564-1642	Galileo who discovered equal speed of falling bodies, telescope and reaffirmed Copernicus' Sun-centered principle.
1567	Paracelsus published On the 'Miners' Sickness and other Miners' Diseases, distinguishing acute and chronic poisoning.
1571-1630	Kepler who stated the elliptical motion of planets around the Sun.
1642-1727	Issac Newton. Principles of gravity, rules of light, optics, calculus etc.
1701-1800	Industrialisation (Mills) started in Britain and spread to the Continent and USA.
1732	First spinning machine by Richard Arcright. Pioneer of industrial revolution.
1749-1838	John Stevance, Father of American Railways.
1761-1828	Nicolas Lui Rober, pioneer of paper industry.
1764	Discovery- of spinning jenny.
1765	Steam engine by James Watt.
1765-1825	Aley Whitney produced sewing, washing and other machines.
1768-1835	Sernual Sletor, Father of American cloth industry.
1771-1852	David Wilkinson, Father of machine tools industries.
1784	Discovery of powerlooms.
1792	Discovery of cotton gins.
1796	Dr. Edward Janner, Small Pox vaccination.
1800-1860	Charls Goodyear, Father of rubber industry.
1801-1874	Gail Borden, Father of modern dairy technology.
1804	President Thomas Jefferson delivered his safety message to Captain Merriwether Lewis.
1806-1873	John Stuart Mill, the great contributor in philosophy of science.
1807	Steam ship by Robert Fulton.
1809-1884	Sirus Hall McCormick, Father of agriculture industry.
1813-1818	Sir Henri Bessimer, Father of steel industry.
1814	Locomotive engine by James Watt.
1819-1880	Edwin L. Derek, Father of Petroleum industry.
1825	Railway usage began.
1830-1850	First attempt to legislate the working hours of women and children in Great Britain.
1831-1879	James Clerk Maxwell, Electromagnetic waves which led us to Radio and TV.
1832-1891	Nicholas August Auto discovered internal combustion engine. Father of automobile industry. Great contribution to industrial revolution.
1833	England, Govt. Factory Inspectorate established.
	George Stephenson suggested use of a steam whistle on locomotives.
1834	England, law enacted to provide fencing for mill gears and shafts. Lord Ashley's Great Factory Act.
1844-1929	Karl Benz made first motor car and called Father of motor car industry.
1845-1923	Wilhelm Rontgen, discovery of X-ray. First Nobel Prize winner in 1901.
1847-1922	Alexander Greham Bell discovered Telephone. Called Father of telecommunication.
1847-1931	Thomas Alva Edison, Father of electrical industry.
1847-1937	Gugli Eimo Marconi discovered wireless telegraph and called father of wireless telegraphy.
1855	Insurance Protection against boiler explosions was afforded in England.
1858-1913	Rudolf Diesel discovered diesel fuel and called father of diesel industry.
1858-1932	Dr Jagdish Chandra Bose. Sensation of plant. Cresco graph to view enlargement of plant movement.

1863-1914	Charles Martin Hall obtained pure aluminum and called father of aluminum industry.
1864	First accident insurance policy in North America.
1865	Benzene ring structure.
1866	National Board of Fire under-writers.
1867	Massachusetts had begun to use factory inspectors.
	Boiler and machinery insurance, started in USA.
1869	Germany-Acts passed providing that all employers furnish necessary appliances to safeguard health and life of employees. Massachusetts (USA) established, the first state bureau of labour statistics in order to determine the kinds and causes of accidents.
	Periodic Table of elements by Mendelif.
1870	Westing house airbrake adopted by the railroads.
1872	First electric automatic signal installed on the Pennsylvania rail board.
1873-1961	Lee De' Forest discovered radio and called father of radio industry.
1874	France, Law enacted providing for special inspection service of workshops.
1876-1920	Willis Havilland Carrier discovered airconditioning and called father of airconditioning industry.
1877	Massachusetts. Law passed compelling guarding of dangerous moving machinery.
1879-1955	Albert Einstein. Quantum theory and principles of relativity.
1879	Electric bulb by Thomas Alva Edison.
1880	American Society of Mechanical Engineers.
1881	American National Red Cross.
	First Indian Factories Act.
1885	Germany Alabama, passed employers' liability law.
	Germany, Bismarck prepared and enacted the first Compulsory Compensation Act for workers. This Act covered only sickness.
1887	Massachusetts passed an employers' liability law.
	Ervin Schrodinger - wave mechanics.
1890	First international conference in Berlin of 15 European States to draw up international conventions on labour regulations.
	Establishment of International Association for the Legal Protection of Workers, the forerunner of the ILO which was established in 1919.
1892	Safety Department of the Joliet Works of the Illinois Steel Company formed. This has been called "The birthplace of the American industrial accident prevention movement". The first safety order was the inspection of all engine flywheels.
1893	Federal Safety Appliance Act required use of standard safety equipment on railroad.
1896	National Fire Protection Association (NFPA), USA.
	Radioactive elements by Cury couple.
1900	US Census of 1900 showed 1750178 working children between 10 to 15 years. Quantum theory by Mex Planck. First safety periodical 'Safety Maintenance' published by Alfred M. Best company.
1901	National Bureau of Standards.
1903	First steel passenger car constructed. Demands of industrial workers were considered in Russia.
1905	Extension of Quantum theory by Einsteine.
1907	Quarterly of the National Fire Protection Association published by NFPA.
1908	Transportation of Dangerous Explosives Act passed.
1909	Aeroplane by Orvil and Vilbar Right brothers.
	First National Conference on Industrial Diseases held.

1910	The oldest large Occupational Health Institute "The Clinica del Lavoro" in Milan.
1911	New Jersey First State Workmen's compensation law passed.
	California passed the first American law for the compulsory reporting of occupational diseases.
	American Museum of Safety.
	Ernest Rutherford - Concept of Nucleus and electron in atom; alpha, beta and gamma rays and many inventions on atomic energy.
1912	Discovery of Thorium, Polonium and Radium by Madam Curry.
1913	Bureau of Labour Statistics.
	'Safety' published by the American Museum of Safety.
	Atomic structure, Nuclear structure and Atomic Model by Nisbohr.
	National Safety Council was founded in USA.
1914	The first World-War started accelerating industrialization and need of safety.
	The first safety of life at sea convention held in London.
1915	American Society of Safety.
	Elliptical motion of electrons by Summerfield.
1918	Air Mail Service started.
1919	National Railroad Accident Prevention Drive inaugurated.
	National Safety News published by the National Safety Council. Then many other publications-started in the subsequent years by NSC (USA).
	International Labour Organi-sation (ILO) was established at Geneva, Switzerland. Hours of Work (Industry), ILO Con.l, Unemployment Con.2, Recom 1, Maternity Protection Con.S, Night Work (Women) Con:4, Minimum Age (Industry) Con.5, Night Work of Young Persons (Industry) Con.6, Anthrax prevention Recom 3, Lead ' Poisoning Recom 4, .Labour Inspection Recom 5, White Phosphorous Recom 6
1921	ILO at Geneva set up a safety service. White Lead, ILO Con. 13, Weekly Rest (Industry) Con. 14.
1922	Greenburg and Smith introduced the impinger, a dust sampling device, which resulted in the impinger method becoming the standard for the US Bureau of Mines and the Public Health Service.
1923	Labour Inspection ILO Recom 20
1925	Workmen's Compensation ILO Con. 17 to 19 and Recom 22 to 25.
1926	Bensol, Poisoning study.
	4:1 accident cost ratio presented by H.W. Heinrich.
	First rocket fly.
1927	A study of the relation between safety and production was made by the American Engineering Council in 1926 and 1927.
1928	First National Aromatic Safety Conference held in America.
	American Standards Association.
	Functioning of International Commission on Radiological Protection (ICRP).
1929	The US Load Line Act passed to prevent overloading of cargo under various conditions.
	The foundation of a major injury ratio 30029-1 indicated by H.W. Heinrich. Peniciline by Alexander Flemming.
	Prevention of Industrial Accidents ILO Recom 31
	Power driven machinery, ILO Recom 32
1930	First Greater New York Safety Conference held in New York city. It was a one day session with 900 attendence.
1930-1934	The ILO published its first Encyclopedia "Occupation and Health", the value of which was widely recognized.

1934	Bureau of Labour Standards.
	Workmen's Compensation revised, ILO
1908	The Air Hygiene Foundation was created to conduct scientific studies to prevent occupational diseases and industrial health. 40 Hours Week, ILO Con. 47.
1936	Holidays with Pay, ILO Con. 52, Recom 47.
1937	Automotive Safety Foundation.
	National Committee on Films for Safety. Safety Provisions (Building), ILO Con.62, Recom 53 to 56.
1938	Centre for Safety Education.
	Nuclear Fission of Uranium by Farmy and Han.
1939	American Industrial Hygiene Association. Labour Inspectorates, ILO Recom 59.
1940-150	Inclusion of Modern Defense Equipment viz.. Radar, jet aircraft, missiles, atom bomb, computer etc.
1941	Industrial Hygiene Departments set up in 33 States (USA).
	The Accident Cause Code was completed by USA. This code introduced an era of accident cause standardization in USA overcoming a weakness in industrial accident prevention that had long existed. National Bureau for Industrial Protection (USA).
1944	Medical Care, ILO Recom 69.
1945	Solid State Transistor by Bell Telephone Laboratories of America. Ultimately this solid state electronics has now come upto the stage of microelectronics using silicon chips and integrated circuits.
	America threw atom bombs on Hiroshima and Nagasaki of Japan causing @ 1,20,000 deaths and more injuries in Aug 1945.
	Tata Institute of Fundamental Research in atomic energy at Bombay.
	DGFASLT. i.e. Directorate General. Factory Advice Service and Labour Institute was set up at Delhi. It was shifted toBomba) (the CLI building) in 1966.
	Foundation of International Air Transport Association (IATA) in Switzerland.
1946	Medical Examination of young person? (Industry & Non-industry), ILO Con.77-79 and Recom 79.
	The oldest Occupational Health Service ii France. Then in Japan in 1947.
1947	Establishment, of International Organisation for Standardi-sation (ISO) by ILO on 24-2-1947. ISO, work is carried out through some 2000 technical bodies and 100000 experts from all over the world More than 4000 International Standard have been published in some 30000 pages Labour Inspection, ILO Con. 81,85, Recom 81, 82.
	ILO conference adopted the first International Standards Concerning the organisation of labour inspection. Atomic Energy Commission (USA).
1948	Declaration of Industrial Policy for small scale industries and public sectors on 6-41948.
	Atomic Energy Commission.
1949	The first national Ergonomics Research Society in UK.
	The ILO published a model code of Safety Regulations for Industrial Establishments for the guidance of Governments and Industry.
1950-60	Establishment of Indian Institutes of Technology at Kharagpur, Bombay, Madras, Delhi and Kanpur, Defense organization. Council of Scientific and Industrial Research and Department of Technology in our country.
1952	Pesticides manufacturing started in India. Social Security (Minimum Standards) ILO Con.102
1953	Protection of workers health, ILO Recom 97 (It includes technical as well as medical measures and compulsory notification of occupational diseases).

1954	Atomic battery (giving crores of electrons per second on transistor wafer) by USA. Atomic Energy Centre was established at Trombay in Bombay. This was renamed as Bhabha Atomic Research Centre in 1967.
1955	Dr. Bhabha was selected as President of the conference on the Peaceful Uses of Atomic Energy at Geneva.
1956	Our first nuclear reactor 'Apsara', the first in Asia also. Welfare facilities, ILO Recom 102
1957	Sputnic the first satellite in the sk/ by Russia. Formation of International Committee for Lifts Regulations (CIRA) in Switzerland. International Atomic Energy Agency (IAEA) came into existence on 29-7-1957 by the statute of United Nations.
1958	Defense Research and Development Organisation. Approval of National Policy on Scientific Research and Development by the Parliament on 4-3-58.
1959	Occupational Health Service, ILO Recom 112. Birth of International Ergonomics Association (IEA) on 6-4-1959 in Oxford. International Occupational Safety and Health Information Centre (CIS) was set up by the ILO Office in May 1959 to collect, disseminate, co-ordinate and distribute world-wide information on occupational safety and health. The service was computerised since 1974. Direct access to CIS data via display terminals and variety of publications are available.
1960	The Regional Labou" Institute (RLI), Madras was set up. Radiation Protection, ILO Con.llS, Recom 114.
1961	The Central Labour Institute (CLI) started in a rented building in 1961 and shifted to its Sion-Bombay premises in 1966.
1962	The Regional Labour Institute (RLI), Kanpur was set up.
1963	Guarding of Machinery, ILO Con.ll9, Recom 118.
1964	Hygiene (Commerce & Offices) ILO Con.l20, Recom 120. Employment Injury Benefit ILO Con. 121 Recom 121.
1965	The Regional Labour Institute (RLI), Calcutta was set up. Formation of International Agency for Research on Cancer by WHO. Medical examination of young persons (underground work) ILO Con. 124.
1966	The National Safety Council (NSC) was established on 4th March 1966, at CLI Building, Sion, Bombay-22. In this remembrance, 4th March is celebrated as the National Safety Day in our country. Electronics Committee at the Chairmanship of Dr. Vikram Sarabhai. First tidal electric plant in France giving 5000 Kwh electricity per year. Foundation of the International Radiation 1978 Protection Asso-ciation (IRPA) in France.
1967	Maximum Weight, ILO Con.l27, Recom 128.
1968	Two conventions on Road Traffic and Road Signs and Signals in Vienna. Agreement on the International Transport of Dangerous Goods by Road (ADR) came into force on 29-1-1968 at Geneva.
1969	Atomic Power Station at Tarapur in Maharashtra. Apollo - II landed on the moon with three scientists, on 21-7-69.. DAE-NASA Satellite - I TV experiment. Report of the National Commission of Labour, India, 1969. Medical care and Sickness benefits, ILO Con. 130, Recom 134. A meeting of editors and users of occupational safety and health periodicals from 21 countries at Geneva on 7-8 July 1969.
1970	Establishment of International Nuclear Information System (INIS) by the IAEA started in 1957.

1971	Electronics Commission under the President ship of Dr. Menon. The Division of Nuclear Safety and Environment Protection started as a division of IAEA. Starting of programme of evaluation of chemical carcinogenic risk to humans. Starting of Science and Technology Department by the Central Government. Benzene, ILO Con.l36, Recom 144.
1972	Foundation of International Association of Labour Inspection (IALI) in Switzerland.
1974	Atomic explosion (experiment) in the desert of Rajasthan. Occupational Cancer, ILO Con.139, Recom 147.
1975	Combination of two space shuttles Apollo (USA) and Soyuz (USSR) in the sky.
1976	Landing of Viking-1 & 2 (USA) on the Mars. Launching of PIACT (International Programme for the Improvement of working conditions and environments). Legislation - The Toxic Substances Control Act 1976 (TSCA) in USA. International Occupational Safety and Health Hazard Alert System was adopted by the International Labour conference.
1977	Gujarat Safety Council was registered on 52-1977 at Vadodara. Working Environment (Air pollution, Noise and Vibration) ILO , Con.148, Recom 156.
1978	International conference on primary health care sponsored by WHO & UNICEF on 129-78. Labour Administration, ILO Con.150, Recom 158. Identification of 4039907 chemical compounds by the American Chemical Society's Chemical Abstract Service (CAS).
1979	Occupational Safety & Health, Dock Work, ILO Con.l52, Recom 160, Hours of Work & Rest Periods (Road Transport) ILO Con.l53, Recom 161. Publication of Initial Chemical substances inventory listing 44000 chemicals, by USA.
1980	The International Programme on Chemical Safety (IPCS) became operational in June 1980, at WHO Head quarters. It is a cooperative venture by UNEP (United Nations Environment Programme), ILO and WHO.
1981	Occupational Safety & Health, ILO, Con.l55, Recom 164.
1982	Maintenance of Social Security Rights, ILO Con.l57. Recom 167.
1985	Labour statistics, ILO, Con.l60. Recom 170. 1996 Occupational Health Services, ILO Con. 161, Recom 171, World Environment (1985), a brochure published by Loksabha, warned about environmental problems. 'Tlie State of India's Environment 1984-85, i.e. the Second Citizen's Report' also threw light on tremendous loss of environment and 1997 human health in our country (see Chap-1).
1986	Asbestos, ILO Con.l62, Recom 172. The Environment (Protection) Act, 1986.
1987	Vital amendments in the Factories Act, 1948 owing to Bhopal disaster.
1988	Safety and Health in Construction, ILO Con.l67, Recom 175.
1990	The Chemicals, ILO Con.l70, Recom 177. Night Work, ILO Con. 171, Recom 178.
1993	Prevention of Major Industrial Accident, ILO Con.l74, Recom 181.
1995	Safety & Health in Mines, ILO Con.l76 Recom 183. Vital amendments in the Gujarat Factories Rules, 1963, in consequence to the 1987 amendment in the Factories Act.
1996	'Down to Earth' report of 15-10-96, warned about environmental losses, air and water pollution and danger to human health (see Chap-1).

'Greenpeace international' report of 10-12-96 threw light on unsafe conditions of our industries and dangers due to chemicals. 3

1997	Landing of arobotic spacecraft. Pathfinder on 4-7-1997, on the red planet Mars by the NASA, USA.
	Launching of a Satellite IRS-ID by ISRO on 29-9-1997.
1998	IS:14489 - Code of Practice on Occupational Safety and Health Audit.
1999	Launching of a Commercial Telecom Satellite INSET-2E by ISRO on 3-4-1999.
2001	Safety and Health in Agriculture Con. 184, Recom 192.
2002	List of Occupational Diseases, Recom 194.
2004	HRD Recom 195.
2006	IS : 15656 Hazard Identification and Risk Analysis.

Reference and Recommended Reading

1. Industrial Accident Prevention. H.W. Heinrich,
2. Encyclopedia of Occupational Health and Safety, ILO, Geneva, Switzerland.
3. Accident Prevention Manual for Industrial Operations, NSC, USA.