Chemical Hazards & Control Measures

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CHEMICAL HAZARDS AND CONTROL MEASURES

5.1.1 STORAGE OF HAZARDOUS CHEMICALS (IN BULK)

The largest quantities of chemicals are available in storage facilities, which may be at factory site or in other isolated storage places. Therefore, it is very important to prevent the loss of containment from storage of hazardous chemicals. The loss of toxic chemical could give rise to the worst kind of chemical industry disaster like Bhopal. Losses through fires in storage result in financial loss rather than loss of life and make relatively less public impact.

There are numerous standards and codes of practice which are applicable to storage. Some of the principles laid down in the standards & codes are highlighted here. The Bureau of Indian Standards has brought out a number of safety codes for chemicals and other hazardous materials.

1. GENERAL CONSIDERATIONS

The objective of storage in a factory is to smooth fluctuations in the day-to-day requirements and availability. If there are no fluctuations, there is no need for storage.

There are basically two basic principles in the design of a storage facility, which are kept in mind: (i) Economic consideration; and (ii) Safety aspects. The types of storage which are economic in these alternative designs may be different and may have different safety implications also. A hazardous chemical stored under pressurized condition may pose comparatively more hazard then the same chemical stored under atmospheric conditions. The chemical will need more space when stored under atmospheric storage conditions and hence will cost more. So a compromise has to be made between the two aspects.

Most of the hazardous chemicals held in storage are flammable liquids or liquefied gases. The code specifies measures to minimize spillages. The vessels and pipe work should be of high standards. The number of connections below the liquid level should be kept to a minimum, preferably just one filling/discharge line if possible. The minimum size connections should be used for draining and sampling. Barrier should be provided to protect the vessel against external damage. Measures to control spillages and fire are also available in the codes.

2. TYPES OF STORAGE

The main types of storage are:		Fluids referred as:
1) Liquid at atmospheric pressure and temperature (atmospheric storage)	-	Volatile liquids
2) Liquefied gas under pressure and at atmospheric temperature (pressure storage)	-	Flashing liquefied gas
3) Liquefied gas under pressure and at low temperature (refrigerated pressure storage, semi refrigerated storage	- -	Semi refrigerated liquefied Gas
4) Liquefied gas at atmospheric pressure and at low temperature (fully refrigerated storage)	-	Refrigerated liquefied gas
5) Gas under pressure	-	Gas under pressure.

A leak of a volatile liquid stored under condition results only in slow evaporation but in case of leak of a chemical stored under condition (4) initial flash off will take and the evaporation will be slow but faster than the first case. In brief the situation will vary depending upon the type of material stored, involved in a leak. The economics of storage of liquefied gases are that it is preferred to use pressure storage for small quantities, pressure or semi refrigerated storage for medium large quantities and fully refrigerated storage for very large quantities.

3. LAYOUT OF STORAGE

The storage, process and terminals should be suitably arranged. The storage should be built on ground able to support the heavy load and located between the process and the terminals. The wind characteristics should also be taken into consideration which reduce the hazard of flammable liquids or vapours.

Segregation

The segregation and separation of hazardous chemicals within the storage area is mainly based on: (i) classification of hazardous chemicals stored; (2) of electrical areas; (3) of fire protection measures.

The classification of hazardous chemicals are based on their physical chemical and hazardous properties like the flash point classification, toxicity rating, UN classification, etc. Electrical area classification into zone 0, 1, and 2 is based on fire hazard potential.

Bunds

In general, bunds are provided for atmospheric storage tanks and for fully refrigerated storage tanks of liquefied gas. Bunds are generally not recommended for pressure or semi refrigerated storage of liquefied gas. The purpose of bund is to retain liquid so that it can be dealt within a controlled manner. Atmospheric storage tanks are generally provided with full bunds. If there are mo0re than one tank inside the bund the capacity should be that of the largest tank after allowing for the displacement due to the other tanks. Low division walls between the tanks within a bund are recommended. Sometimes it may not be practicable to provide full bund capacity, under that circumstance use may be made of a separate impounding area into which a liquid spillage may be run.

The bund should be far enough from the side of the tank to prevent a jet of liquid jumping over. The corners of the bund should be rounded. The bund should be provided with drainage connection, with a valve on the inlet end but outside the bund wall. Walls of the bund should not be so high to hinder fire fighting. In some literature the maximum height is given as 2 metre. There should be minimum two access points on opposite side of the bund to allow safe access/escape in all wind direction.

For pressure storage vessels containing LPG a full bund is not recommended because after spillage a large amount of liquid will remain after the initial flash off. For example, 67% of propane will remain in liquid form after an initial flash off from a pressure storage tank of propane at 16^{o}C (Theoretical).

Fully refrigerated storage tanks containing liquid ammonia should also be provided with a full bund.

Separation distances

Minimum recommended separation distances for storage are given in various codes and other publications. In India, safety distances for pressurized (toxic, flammable & corrosive chemicals) storage is given in the Static and Mobile Pressure Vessels (SMPV) Rules (Table – 1).

Two main factors which could determine separation are (1) Heat from burning liquid; and (2) Ignition of vapor escape. To get exact separation distances for storage engineering calculations are done based on direct impingement and on heat radiation.

The minimum recommended separation distance for storage tanks for class A and B flammable liquids are given in Table – 2. (Institute of Petroleum, 1965, Refining Safety Code).

T A B L E – 1

Minimum safety distances for flammable, corrosive and toxic cases

Sr. No.	Water capacity of vessels (in litres)	Minimum distance from building or group of buildings or line of adjoining property	Minimum distance between pressure vessels
i.	Not above 2,000	5 metres	1 metre
ii.	Above 2,000 but not above 10,000	10 metres	1 metre
iii.	Above 10,000 but not above 20,000	15 metres	1.5 metre
iv.	Above 20,000 but not above 40,000	20 metres	2 metres
v.	Above 40,000	30 metres	2 metres

T A B L E – 2

Sl.No.	Factor	Type of tank roof	Minimum distance
1.	Distance between tank and building containing flammable material e.g. filling shed or storage building.	a) Fixed roof b) Floating roof	A minimum of 50 ft. (15 m.) A minimum of 20 ft. (6 m)

2	Distance between tank boundary or any source of ignition	Both types	A minimum of 50 ft. (15m) any source of ignition irrespective of should not be within distance the bund.
3	Maximum tankage capacity in one bund	a) Fixed roof b) Floating roof	60,000 ton water capacity 120,000 ton
4	Volume of bund	Both types	Net volume not less than 100% of capacity of the largest tank.

Other aspects

Division walls can be used to divert large vapor flows to areas where they can be dealt with more safety. Steam curtains are considered as a means of maintaining separation from an ignition source. Fire walls are utilized to give protection against flame or heat radiated from a fire.

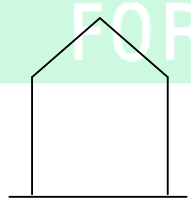
4. STORAGE TANKS AND VESSELS

The main types of tanks and vessels for liquids and liquefied gases are (1) atmospheric storage tanks; (2) low pressure storage tanks; (3) pressure or refrigerated pressure storage tanks; and (4) refrigerated storage tanks.

Atmospheric Storage

Atmospheric storage tanks are of two types, namely (1) fixed roof tanks; and (2) floating roof tanks. Atmospheric tanks are designed to withstand an internal pressure/vacuum of not more than 1 psig.

Fixed roof tank –



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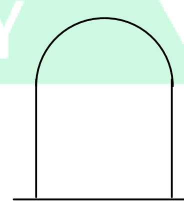

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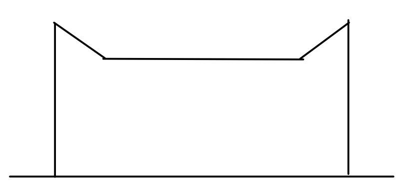
Vertical Fixed Roof Tanks

Floating roof tank –

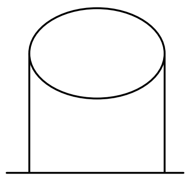


Low pressure storage

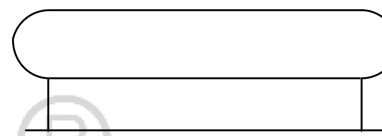
Low pressure tanks are designed to withstand internal pressure in the range of 0.5-15 psig. Use is also made of low pressure tanks in refrigerated storage, as described below.

Pressure and refrigerated pressure storage

Pressure storage vessels are regular pressure and can be designed to high pressure as required. The lower end of the scale for pressure storage is 15 psig. Horizontal cylindrical vessels have a relatively limited capacity. And for larger quantities spheres are used.



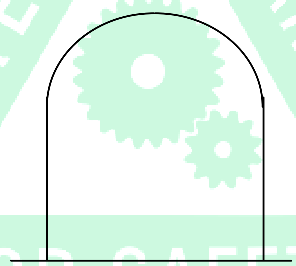
Horton Sphere



Horizontal Cylindrical Pressure Vessel

Refrigerated Storage

This is domed roof, flat bottomed tank. It is essentially an atmospheric storage tank, with a design pressure below 1 psig.



Vertical Fixed Roof Refrigerated Atmospheric Tank (Domed Roof)

5. SAFETY FEATURES – ATMOSPHERIC STORAGE VESSEL

Atmospheric Venting

A fixed roof atmospheric storage tank is connected to atmosphere by a vent to prevent the tank from overpressure at the time of filling and emptying, respectively. The vent should always be kept free from the blockage.

Pressure / Vacuum Valves (PV)

A fixed roof tank containing volatile liquid breathe heavily. To prevent vapor loss a PV valve is effective. The blockage of the valve should be avoided.

<u>Flame Arrestor</u>

If the vapor space above the liquid in a fixed roof atmospheric storage tank contains a flammable mixture, there is a possibility that it will be ignited via the vent. A flame arrestor may be used to prevent this.

Fire Relief

Fixed roof tank should also be provided with certain arrangements to prevent it from getting damaged/pressurized due to heat in case of fine. In practice it is done by making the seam between the shell and the roof weak so that it is the first to rupture. This is known as rupture seam arrangement.

6. SAFETY FEATURES – PRESSURE STORAGE VESSEL

A pressure storage vessel should be protected against overpressure. Protection is required against overpressure due to : (1) abnormal operating conditions; and (2) fire exposure. It may be provided by a single relief valve or by separate relief valves for each category.

Operational Relief

Over pressurization of storage vessel may take place due to abnormal operating conditions like overfilling, high rundown liquid temperature, high tank liquid temperature due to solar radiation, etc. A proper sized relief valve should be provided to protect the storage vessel against over pressurization.

Fire Relief

A storage vessel may get exposed to fire and may get overheated. The heat will generated a lot of vapors inside the vessel, which will subject the vessel to a high degree of pressure. The vessel has to be protected against over pressurization under such conditions. A proper relief valve should be provided to take care of such problem.

Combined Relief

If a single relief valve is used to provide both operational and fire relief, it should be set to open at 100% of design pressure and the relieving capacity should be at least equal to the greater of the individual capacities required for operational and fire relief.

Relief Discharge

An operational relief valve and a fire relief valve should discharge into a closed system with proper treatment facilities. The idea is to prevent the environment from getting polluted.

7. PIPEWORK AND FITTINGS

The pipe work, valves and other fittings for storage systems should be designed in accordance with approved practice for such equipment. The following aspects should be considered:

1. Minimum & Maximum temperatures which may be attained.
2. Materials of construction
3. Allowances in pipe work for stresses due to movement, expansion/construction and vibration.
4. Joints (flanged joints should be kept to a minimum)
5. Size of pipelines, depending on filling/discharge and drainage

6. Number of pipeline below the liquid level. If possible only the pipeline in a storage vessel.
7. Liquid expansion valves between shut-off valves.
8. Access to valves
9. Protection against mechanical damage.

8. ANCILLARY EQUIPMENT

In storage installations the main types of ancillary equipment are pumps, refrigeration compressors and vaporizers. Pumps are a potential source of leakage of flammable vapors. A pump should be provided with a bypass discharge line back to the storage, to prevent the pump getting hot, if pumping against a closed valve. Pumps should be located outside the bund.

9. FIRE PREVENTION AND PROTECTION

Fire protection of storage has several objectives. These are: (1) to minimize hazard to personnel; (2) to minimize loss due to the initial fire; and (3) to prevent spread of fire to other vessels and equipment. Personnel are at risk principally from an explosion or sudden spread of fire.

5.1.2 HANDLING OF HAZARDOUS/DANGEROUS CHEMICALS

1. INTRODUCTION

Due to rapid technological development, a large number of chemicals are being used in industries. The number and variety of chemicals industries manufacturing fertilisers, pesticides, petro-chemicals, pharmaceuticals, dyestuffs, explosives, etc. are sources of different levels of hazard potentials. Major accident that are likely to be caused by these dangerous/hazardous chemicals. Chemicals due to their storage and handling are fire, explosion and toxic release (i.e. health hazard) depending on the nature of the chemicals. Chemicals, in any form, can be safely stored, handled and used if their physical, chemical and hazardous properties are fully understood and necessary precautions, including use of proper safeguards and personal protective equipment are observed. Adequate care and attention is necessary in handling hazardous / dangerous chemicals. To eliminate or reduce hazards while handling these chemicals it is advisable to have standard processing and operating methods, adequate maintenance of equipment and above all strict compliance of laid down safety procedures.

Hazards of handling dangerous/hazardous chemicals fall under two broad categories viz.

(a) danger due to fire, explosion or toxic release of the chemical, and
(b) danger due to chemical action of the substance on human body either by direct contact or by inhalation.

2. CLASSIFICATION OF CHEMICALS BASED ON HAZARDS

(a) Flammable chemicals
(b) Explosive chemicals
(c) Corrosive chemicals
(d) Toxic chemicals
(e) Heat sensitive Chemicals
(f) Oxidising chemicals (agents)
(g) Water sensitive chemicals
(h) Gases under pressure
(i) Chemicals liable for spontaneous ignition
(j) Reducing chemicals (agents)
(k) Radio-active substances

3. CARE & PRECAUTIONS NEEDED TO HANDLE DANGEROUS/HAZARDOUS CHEMICALS

The following points need to be considered while handling dangerous / hazardous chemicals:

(a) Dangerous chemicals should be handled and stored under the supervision of a competent person who is familiar with the risks and the precautions to be taken.
(b) 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 competent authority.
(c) 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.
(d) Special precautions, such as, the provisions of mats, sling nets, boxes and high sided pallets, should be taken to prevent breakages or damages to containers of dangerous chemicals.

(e) If containers of dangerous chemicals are broken or damaged to avoid a dangerous accident work should be stopped and the workers concerned removed to a safe place, until the danger has been eliminated.

(f) When highly flammable material is being handled, special measures should be taken to ensure that an incipient fire can be controlled immediately.

(g) Where necessary, non-sparking tools should be provided, and used in explosive atmosphere.

(h) Where corrosive substances are handled or stored, special precautions should be taken to prevent damage to the containers and to render the spillage harmless.

(i) Workers handling harmful substances should thoroughly wash the hands and faces with soap before taking any food or drink. All spillage should be promptly neutralised and finally, washed away safely.

5.1.3 (a) TRANSPORTATION OF HAZARDOUS CHEMICALS

1. INTRODUCTION

Transportation of hazardous chemicals, dangerous goods or hazardous goods requires special care and attention in terms of their labelling, marking and transporting (i.e. shifting from one place to another)

2. INDUSTRIAL CLASSIFICATION OF LABELLING

2.1

The labelling and marking by means of warning symbols or text of containers or system that hold dangerous substances are essential safety precautions. After a dangerous substance has been loaded or packaged and dispatched by manufacturer and before it is used by the consumers, it may be handled by a number of workers who have no idea of the nature of product or of dangers it may present. The workers engaged in manufacture may be aware of the hazards associated with chemicals and may take appropriate precautions during its manufacture, packing, dispatching. However, persons handling the substance during its transport or transit operation are not aware of the hazards and the nature of the contents, unless an identification and warning label or mark is provided. Similarly persons using the substances may also be unaware of the hazards involved or of necessary precautions to be taken.

Hazard warning is an essential requirement in worker protection, but should not be considered to provide complete protection in itself or to make it unnecessary to enforce safety measures commensurate to the risk.

Labelling systems are usually based on certain hazardous substance classification scheme and have an objective to provide workers and general public with explicit information on the main hazards of the substances in question. Many countries have long standing regulations or codes governing the labelling of dangerous substances with particular regard to transport requirement. These provisions were originally drawn up at a national level and consequently, there was a lack of uniformity between requirements in different countries. As international trade developed, the need for a harmonization of national requirements and for the establishment of an international system became evident. This need was particularly acute in the case of symbols used to warn of specific hazards, since such symbols can be used to overcome problems posed by communication in a number of different languages. It has been, for sometime, recognized, that in international trade, graphic symbols are essential for indicating the main hazards of dangerous substances.

2.2 UN CLASSIFICATION OF DANGEROUS SUBSTANCE

In 1952, the United Nations Economic and Social Council appointed a committee of experts on the Transport of Dangerous Goods. Recommendation of this committee while not proposed purely and simply as a substitute for national and international regulations are designed to provide guidance for governments and international bodies. The governments and international bodies have framed or are drafting regulations so as to achieve at least a minimum of uniformity throughout the world for various modes of transport.

Classification of Dangerous Substances

The classification recommended by the UN Committee of experts is as follows:

Class – I	:	Explosives
Div.1.1	:	Explosives with a mass explosion risk.
Sub division 1.1.1	:	Initiating explosives contrivances which contain both explosives and their own means of ignition.
Sub division 1.1.2	:	Explosive substances other than initiating explosives contrivances containing explosives but not their own means of ignition.
Sub division 1.1.3	:	Contrivances designed to produce illumination, incendiary, smoke or sound effects, ignites, starter cartridges, small arms ammunition, fireworks liable to explode violently.
Division 1.2	:	Explosives which do not explode en-mass having a projection hazard but minor explosion effect.
Sub division 1.2.1	:	Contrivances containing explosives with or without their own means of ignition.
Sub division 1.2.2	:	Samples of explosive other than initiating explosives.
Division 1.3	:	Explosives which do not explode en-mass having a fire hazard with minor or no explosion effect.
Division 1.4	:	Explosive which present no significant hazard
Sub-division 1.4.1	:	Covers item which are so packed or designed as to present only a small hazard in the event of ignition during transport.
Sub-division 1.4.2	:	Covers safety explosives
Class – 2	:	Gases compressed, liquefied or dissolved under pressure.
Class – 3	:	Inflammable liquids.
Class – 4	:	Inflammable, solids, substances liable to spontaneous combustion, substances which on contract 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.
Division 5.1	:	Oxidising substances other than organic peroxide.
Division 5.2	:	Organic peroxide.
Class – 6	:	Poisonous (toxic) and infectious substances
Division 6.1	:	Poisonous (toxic) substances.
Sub Division 6.1.1	:	Substances which give off a poisonous (toxic) gas or vapour.

Sub Division 6.1.2	:	Poisonous ((toxic) substances other than those giving off poisonous (toxic) gas or vapours.
Division 6.2.	:	Infectious substances.
Class – 7	:	Radioactive substances.
Class – 8	:	Corrosives
Class – 9	:	Miscellaneous dangerous substances

3. TRANSPORTATION OF GOODS OF DANGEROUS OR HAZARDOUS NATURE

Transportation of goods of dangerous or hazardous nature to human life should be done as per the provisions under the Central Motor Vehicle Rules, 1989 framed under the Motor Vehicles Act, 1988. Important provisions regulating transport of dangerous/ hazardous goods are :

i) Educational qualification and training of drivers carrying the goods

ii) Responsibility of consigner for safe transport of dangerous or hazardous goods

iii) Responsibility of the transporter or owner of goods carriage

iv) Responsibility of driver

v) Emergency information panel

vi) Driver to report to nearest police station in case of accident during transportation

vii) Spark arrester to be filled to every goods carriage

5.1.3 (b) PROCESS SAFETY – AN OVERVIEW

1. INTRODUCTION

Within the past ten or fifteen years the chemical and petroleum industries have undergone considerable changes. Process conditions such as pressure and temperature have become more severe. The concentration of stored energy has increased. Plants have grown in size and are often single-stream. Storage has been reduced and interlinking with other plants have increased. The response of the process is often faster. The plant contains very large items of equipment. The scale of possible fire, explosion or toxic release has grown and so has the area which might be affected by such events, especially outside the works boundary.

The factors have greatly increased the potential for loss both in human and in economic terms. This is clear both from the increasing concern of the industry and its insurers and from the historical loss statistics.

The industry has always paid much attention to safety and has a relatively good record. But with the growing scale and complexity involved in modern plants the danger of serious large-scale incidents has been a source of increasing concern and the adequacy of existing procedures has been subjected to an increasingly critical examination.

It is against this background that the loss prevention approach has developed. It is characteristic of this approach that it is primarily concerned with the problems caused by the depth of technology involved in modern processes and that it adopts essentially an engineering approach to them. As far as possible both the hazards and the protection are evaluated quantitatively.

This paper gives a brief account of the various factors relating to process hazards and their control measures.

2. NEED FOR CONSIDERATIONS IN THE DESIGN STAGE

With rapid advance in technology, more severe pressure and temperature conditions, increase in concentration of stored energy, larger and more integrated plants and complex process technology have come to stay. The scale of hazards due to fire, explosion or toxic release has grown. Hence, early identification of potential hazards, evaluation of their magnitude and consequences have become necessary right at the design stage.

The economics of eliminating a hazard when first identified depends upon the stage of the project. Hence identification of hazard should start at the process development stage itself. It is not only important to start hazard identification from the conceptual stage but also continue through different stages of design.

3. IDENTIFICATION OF PROCESS HAZARDS

This is mainly based on the inventory of hazardous substances stored or processed or in transit at the industrial site. The hazardous substances are broadly classified as :-

(a) Very toxic
(b) Toxic
(c) Highly reactive and explosive
(d) Flammable

For identification of the hazards, at different stages, the following factors have to be taken into consideration :-

i) Uncontrolled exothermic reaction
ii) Loss of containment
iii) Ignition sources
iv) Corrosion, erosion and excessive vibration
v) Size and layout of the equipment.
vi) Uncontrolled factors like accident in adjacent facilities and natural calamities.

The hazards presented by chemicals, reactions, presence of impurities could be studied in detail in the R & D stage and the results verified though pilot plants.

4. STEPS TO PREVENT MAJOR ACCIDENTS DUE TO PROCESS HAZARDS

1. Proper design, construction, inspection, maintenance and operation of storage vessels and process plants.

2. Preventing potentially hazardous excursions from normal operating conditions, leading to a major accident (provision of alarms, trips, scrubbers, etc.)

3. Measures aimed at an incipient major accident to limit its consequences e.g. water curtains, emergency procedure.

4. Following appropriate standards or code of practices.

5. Restrictions on development in the vicinity of Major Hazard Installation.

6. Maintain complete information on the metallurgical phenomena of metals used in the plant reactors and vessels used for storage.

7. Limit the number of people at risk.

8. Maintain high standards of operation, maintenance and testing.

9. Limiting inventories to optimum level for inherent safety of the plant.

5. SITE SELECTION AND DEVELOPMENT CONTROL

Handling of large quantities of hazardous materials always involves risk. Even though the risks may be reduced by good design they cannot be totally eliminated.

The surest way of reducing the exposure of the population to these more undesirable effects of industry is to site it well away from the community. This is not always possible in view of the other conflicting factors in the planning, such as reduced travel time, transport and service infrastructure, industrial zoning and preservation of country side.

Many industries have grown in scale within their existing sites and over the years, the neighbouring community development has tended to encroach even closer to industrial complexes.

While selecting the site, the environmental impact, the accident scenario, domino-effect and effects of dominant wind direction are to be taken into consideration.

Development Control

A zone should be established around the major hazard installations at a distance determined according to the consequence criteria.

As a guide to the size of zone envisaged where LPG is the hazard, it would vary from 300 - 1500 metres around the installation, depending on the latter's inventory. For flammable gases, the corresponding figure would be about 500 metres; for toxic gases (e.g. chlorine), 1000-1500 metres, for highly reactive substances (e.g. organic peroxides) 250 metres and for highly flammable liquids, 250 metres.

6. ISSUES RELATING TO PROCESS HAZARDS AND THEIR CONTROL

1. Plant Integrity

It incorporates approved design standards, use of protective devices such as pressure/vacuum relief valves, bursting discs and similar mechanism. This is particularly important where pressurized systems are involved. Since these devices are required to operate when process control fails, it is important to test them regularly. Inspection and testing vessels, pipe lines, pumps and plant modifications are also a must.

2. Operating Procedures

This refers to the necessity of operating instructions for each installation facility. These instructions should describe the sequences of flow of the work, the conditions to be maintained, actions of the various control and monitoring instruments, specify the allowable excursion limits and the action to be taken in case they are reached and specify the emergency procedures and operator training modalities.

3. Process Deviations

All foreseeable process deviations should be considered for their effects on the installations, particularly in relation to loss of containment. The most important process deviations are those concerning chemistry, process, temperatures, flow rate and liquid level. Hazard and operability study is an important tool to identify all foreseeable process deviations which may lead to loss of containment and major accidents.

7. SAFETY CONTROL DURING PROJECT DEVELOPMENT

Various safety controls exercise during the different stages of project Development should start from the conceptual design stage itself and continue through the other phases of engineering execution, start-up and operation of the plant.

In the conceptual or pre-design stage, Hazard Ranking through Hazard Indices, Hazard studies like HAZOP and Environmental Impact Assessment would be useful. In the design stage, Process Design Checks, HAZOP, Failure Mode and Effect Analysis, Fault Tree analysis, Event Tree Analysis and Reliability Assessment could be undertaken. During the start-up/commissioning stage, Safety Audit, Mechanical Commissioning Tests, Non-destructive Testing and Emergency Planning Organisation details could be taken up. The operational stage checks may include Safety Audit. Calibration of vital meters, condition and corrosion monitoring. Analysis of the past histories of failures of similar systems would give a lot of ideas on effecting the modifications on the system.

1. Plant Commissioning

The important requirements are :

i) Checking up drawings
ii) Safety audit
iii) Scrutiny of modifications
iv) Operating Personnel Training
v) Emergency planning
vi) Start-up Teams
vii) Assessment of failure rates of safety systems like valve, etc.

Not only the individual safety devices are tested, but the anticipated failure modes have to be simulated and the adequacy of engineered safety systems verified. Short falls are to be corrected before operation.

1. Operation and Maintenance

Require detailed written procedures before operation. Train all the plant personnel to use permits for any maintenance job. A consolidated safety checklist is helpful for compliance at different stages.

8. SAFETY IN THE DESIGN OF PLANT AND EQUIPMENT

The plant should be designed, constructed, inspected, tested and certified as necessary to an appropriate design and construction code which will achieve the safe working limits.

1. Hardware Design

For equipment and hardware design, guidance could be taken from the various national and international standards. Codes of practices, statutory laws and standard publications, like IS, BS, ASME, ASIM, DIN, JIS and so on. Deviations from the code at the fabrication, erection and testing stages is not unusual. While approving concessions, the approach for safety related equipment has to be different than that for other areas. What is permissible purely from process or economic considerations may not hold good for safety related areas.

2. Pressure Vessels

Incorrect design and materials could lead to all the known modes of failure. Protective devices may include pressure/vacuum relief valves, bursting discs, explosion vents, high/low level alarms, high/low temperature alarms, weight tables, contents gauges, maximum fill devices and many forms of instrumentation. For example, a bursting disc of the wrong design or wrongly fitted may not relieve at the maximum working pressure.

3. Pipelines

Pipelines containing hazardous fluids should be designed and constructed to an appropriate standard. Particular causes of failure are inadequate allowance for expansion/contraction, inadequate supports, metal thinning due to corrosion/erosion. Poorly-made joints and inadequate inspection. The safe working limits of pressure, temperature and loading should be known and protective devices fitted where excursion is foreseeable. Any modifications or extensions made should be of a reliable system for unambiguous identification of pipelines.

4. Pumps and Ancillary Equipment

If failure could create a hazardous situation by less of fluids or loss of pressure, standby equipment should be provided. If standby equipment is not provided, planned or preventive maintenance systems should be followed. The design parameters of the pump and equipment should be suitable for the particular fluid being processed and the duty demanded. Emergency procedures should be available in the event of pump or equipment failure.

5. Modifications to Plant and Equipment

Modifications to plant and equipment should be carried out to a standard at least equivalent to the original integrity, or the plant down-rated accordingly. On completion, the modifications should be inspected and/or tested by a competent inspection authority and approved for use and details recorded. The modifications should be subjected to at least the same inspection and maintenance procedures as the remaining plant.

6. P & I Safety Review

A safety review of the various components of the piping and instrumentation would reveal the important requirements to be complied within the design stage. The items to be considered may include emissions, emergency releases, interlocks and trips, provision of spares for critical equipment, metallurgy and design conditions.

In a hazardous processes plant, uninterrupted power supply is a must for a number of critical process operations. Hence it is important to provide for emergency power in case of interruption of normal power supply. Due consideration is to be given to the provision of facilities for fire fighting, fire protection, maintenance, alarms and communication facilities during the engineering design and construction stages.

7. Procurement and Inspection

The manufacturer should be supplied with sufficient information to be able to design/select the equipment correctly. The inspection is to be carried out by qualified and experienced professionals. All stage-wise inspections, materials test certificates and results of destructive and non-destructive testing should be well documented. Heat treatment and special tests such as impact testing, radiography or stress relief should be observed with special care. The calibration and accuracy of inspection tools and instruments are to be checked periodically.

9. EVALUATION OF PLANT THROUGH RISK ANALYSIS

The planning, design and control of Major Hazard Installations require an objective analysis of the potential for adverse effects and their likely frequency of occurrence. This is achieved through the techniques of hazard analysis, risk assessment and monitoring through a program of audits.

Most of the techniques developed are designed for application of specific projects for different development phases such as conceptual design and planning, detailed design, construction, commissioning and operation. The purpose is to carry out each analysis at such a stage in the project that it is still possible to make the particular types of changes that the analysis may suggest. For e.g. an analysis of risk to the public is most useful during early planning, when sitting and layout are not yet fixed.

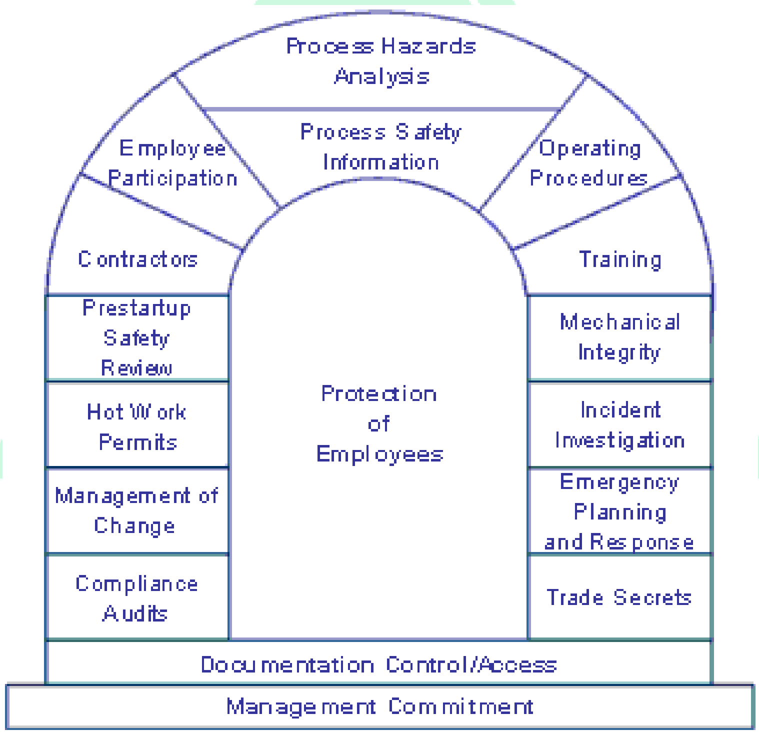
Some of the techniques that could be usefully applied are:

i) Hazard survey/Hazard inventory
ii) Design checklist
iii) HAZOP / FMEA
iv) Reliability studies
v) Systems reliability / Fault tree analysis
vi) Event tree analysis
vii) Cause-consequences diagrams
viii) Risk assessment
ix) Construction audit / Pre-commissioning check
x) Safety audit.

10. EMERGENCY PREPAREDNESS

Ensuring safety at every stage of the plant would very much include the planning and efforts undertaken in limiting and mitigating the consequences of a major accident. The first and foremost in this direction is to have a proper arrangement for sensing and alerting people in the shortest possible time to a developing state of emergency.

This calls for sensing instruments, strategically located and indicated locally and centrally. There should be a system of communicating this to the surrounding areas as well.



5.2 WORK PERMIT SYSTEM

1. INTRODUCTION

Serious accidents, often resulting in fatalities have occurred and continue to occur repeatedly while performing certain types of jobs under certain conditions. Therefore, to control and prevent the repetitive accident occurrence, some positive means of safe-guard and controlling measures are necessary. As a result, the work permit system dawned from the experiences of several industrial workers who have made supreme sacrifices for want of an established work permit system. (The work permit system proved to be one of the more satisfactory methods of ensuring positive controls over hazardous operations performed in unfavourable conditions. Moreover, the system helped to affect greater controls on execution of jobs, maintenance and repair works performed simultaneously on the same equipment by different trades and sections under separate supervisions.

2. WHAT IS A WORK PERMIT

"Work Permit" is essentially a document that, categorically spells out the task, equipment involved, its location, personnel involved, time limitations, precautionary measures to be taken together with likely hazards to be encountered it any.

3. USEFULNESS OF PERMIT

Work permits provide written information on the prevalent hazards connected with the job performance. It spells out the suitable remedial measures to be adopted to encounter the hazardous conditions that are prevailing or that can be encountered while performing the job. It also stipulates various conditions and limitations on the part of personal protective equipment to be used at different stages of work.

It serves as a predetermined checklist for various safety precautions to be taken. It also serves as media of information to all concerned in advance. It provides a written record of the operation including the personnel who were involved in authorizing and carrying out the operations. The permit system (which necessitates carrying out of various tests and safe guards) instils a sense of security from accidents in the minds of the crew performing the job.

In a nut-shell, the work permit system offers one of the best methods to meet all the various conditions required for making a hazardous operation safe and easy to perform.

4. TYPES OF PERMIT

Depending on the type of industry and the hazardous operations carried out, various types of permits have been developed to suit the individual industry's needs. However, the most commonly used permits are:

a) Fire permit or Hot Work Permit
b) Safe Entry Permit or Vessel Entry Permit
c) Excavation Permit
d) Electrical Work Permit
e) Acid Area Work Permit
f) Safe Work Permit or Work at Height Permit- and so on

5. WHO ISSUES PERMITS & TO WHOM

Permits are issued by supervisors having proprietary responsibility of areas and equipments. It is generally issued in the name of a Supervisor or Technician who is to carry out the required job under the known hazardous conditions.

6. WHAT DOES A PERMIT CONTAIN

A permit contains written information and instructions pertaining to hazards that are to be avoided in a particular operation. It indicates that all hazards have been considered in advance and that foreseeable appropriate precautionary measures have been taken. People responsible to execute a job defined in the permit are to review them from the point of compliance. In other words, a permit is a written consent of the proprietor that guarantee proper and safe conditions where personnel can work safely by complying with the instructions on the permit. Similarly, it also indicates that the people executing the job have reviewed the permit and accept responsibility of adhering to the instructions and limitations stipulated. Thus a permit finally becomes a document of consent by both parties, i.e. the proprietor and job executor.

7. PERMITS AND THEIR ISSUE

7.1 Fire permit or Hot Work Permit

Fire permit or hot work permits are issued to authorize carrying out of welding, gas cutting, working with open flames or other works like grinding, chiselling etc that release sparks, in such areas and equipments where hot work under normal conditions is considered to be dangerous. Usually a Fire Permit will be necessary to carry out hot work, in, on or around :

a) No smoking areas
b) Equipment and piping in hydrocarbon service
c) Rubber lined equipment
d) Equipment and piping in acid service

It will be the responsibility of the originator, i.e. the Operating Department to make the area or equipment, (where hot work is intended to be carried out) free from fire hazard and explosion. Therefore, before a hot work permit is released, generally the following points are given utmost consideration :

a) the equipment/area and their surroundings are tested to determine the explosive range. This can be achieved by testing with an explosive meter or taking air samples and tested in the Laboratory. In case of presence of explosive mixture in the air, no hot work will be permitted till such time the area is made free of explosive content by cleaning, ventilating, purging etc.

b) all pits, pumps, openings etc. in the vicinity are covered with fire proof material to prevent sparks entering and causing explosion and fire.

c) the area and the surrounding are sufficiently wetted to facilitate extinguishment of sparks, hot slugs etc as they fall.

d) adequate first-aid fire fighting equipment are kept readily available for use in case of need. If the crew carrying out the repair work do not know how to operate the fire fighting equipment, men with fire fighting knowledge are made available at the work spot during the repair work.

7.2 Safe Entry or Vessel Entry Permit

Under the provisions of Section 36 of The Factories Act, 1948 no person shall be permitted to enter into a place classified as a confined space unless and until all measures have been taken to make the equipment/vessel adequately safe for working. The Act also stipulates that a written certificate is to be given by the competent person stating that the space is made free of all hazards and is fit for persons entering it.

Usually the Supervisor having the proprietary control over the equipment/vessel issues a Safe Entry Permit and authorizes entry and work in, on and around a confined space. Before issuing such a permit, it will be his responsibility –

a) to isolate the equipment/vessel from all sources, through which any energy, stock or harmful substances can get introduced, by disconnecting, blinding, blanking etc.

b) to drain, clean, wash and purge the equipment / vessel to make it free from toxic gases and other harmful substances.

c) to test the air inside the vessel to determine presence of explosive mixture, oxygen content etc. In case of presence of explosive mixture or deficiency of oxygen, it should be further ventilated, till such time the explosive mixture is removed or the oxygen content increased to a minimum level of at least 17 per cent.

CAUTION : Sweetening the air in confined space with oxygen from a cylinder shall never be attempted.

d) In case of deficiency in oxygen that cannot be improved upon, entry into the vessel/equipment should be strictly restricted to the usage of adequate breathing apparatus, and the usage of breathing apparatus should also be restricted to self contained breathing apparatus or a Supplied Air Line Respirator.

e) as far as practicable two man ways or other openings on the equipment/vessel should be kept open for cross ventilation.

After ensuring all the above points, the operating Supervisor should prepare adequate number of safe entry permits and display conspicuously at each point of entry. Any other precautions to be taken for entry should be clearly specified on the permit. Persons entering into a vessel/equipment, that has been declared as safe to enter by exhibiting safe entry permit, must read the safe entry permit carefully and strictly obey and comply with all the instructions detailed on the safe entry permit. Where reading by all concerned becomes a problem suitable signs may be used.

7.3 Excavation Permit

In most industries, pipe lines, electrical cables, telephone cable etc are run under ground. In some cases where goods are not stable or contaminated, digging and excavation work may cause accidents and/or property damage. Hence, to prevent such accidents, injuries or property damages the digging and excavation works are controlled by permit system. Industries having permit systems to control excavation work, forbid as a rule, any excavation work whatsoever, within the factory premises without a valid Excavation permit.

Here again, the originator of the permit will be the Supervisor having proprietary responsibility of the area where excavation work is intended to be carried out. The originator after preparing the Excavation Permit in duplicate, indicating the exact location where the excavation work will be carried out, sends both copies of the permit to the Engineering Department. The Plant Engineer studies the relevant drawing of the area to be excavated and determines whether any pipe lines or cables are located in the area. If any such obstacles are seen, he prescribes the special precautions to be taken while excavating, and puts his signature on the permit. One copy of the permit is retained by the originator and the duplicate handed over to the agency executing the job. The duplicate copy, in fact, is held in the possession of the person who actually carries out the job at the work site. The permit is required to be produced for inspection and checking when demanded by the concerned authorities.

7.4 Electrical Work Permit

Work on electrical installations, equipments and apparatus is considered to be very hazardous. Therefore, it is of utmost importance that sufficient safety precautions are taken before carrying out any work on, electrical circuits, lines and equipments. More so, when the power is of high voltage. Hence, to exercise greater control over such work and to ensure that adequate precautionary measures are taken before commencement of work on electrical equipment, an Electrical Work Permit known as 'Permit-to-work' has been developed. The model form of Permit-to-work is given in Appendix-B of Indian Standard 5216 of 1969.

Generally the department vested with the responsibility of power generation, distribution, control etc. originates a "Permit-to-Work" to authorize maintenance and repair work on electrical circuits and other equipment operated electrically. The permit is normally issued in the name of a person of Electrical Engineering Section who is required to carry out the job.

Before issuing permit-to-work and authorizing work, the originator ensures that the apparatus concerned is made dead, isolated from all live conductors and has been connected to earth. To make an apparatus/equipment dead, all the relevant switches, isolators, breakers, fuses, back fee switches etc are opened out and the isolated section earthed at each isolation point.

Having carried out the above procedure, the originator rechecks again and satisfies himself that the apparatus has been made dead and there is no possibility of inadvertent introduction of power. Then, only he issues the Permit-to-Work and authorizes the repair work.

Responsibility of the Electrical Engineering

Person detailed to carry out the repair work as indicated on the permit-to-work, on receipt of the permit, goes through the entire process of rechecking to ensure that in effect the equipment / apparatus has been made dead, isolated and earthed as mentioned in the permit. Having fully satisfied, that the equipment/apparatus is made safe to commence work, the person in-charge of repair work attends the job.

Work over-lapping to next shift

In case when the work could not be completed within the same shift, the permit can be transferred on the name of another person who would be continuing the job. The fact, that the permit has been transferred to another person is noted on the permit. The person transferring and the person receiving the permit, both on the permit.

Return of Permit

On completion of the job, the person in-charge of the repair job at the time, ensures that, all men working on the equipment/apparatus have been withdrawn, all earth and other connections made by him or his men have been removed and he returns the permit the cancellation. The permit issuing authority, on receipt of the permit for cancellation, rechecks the equipment/apparatus and cancels the permit. He then energises the equipment/apparatus made dead earlier for repair work, by removing the earths made for the purpose and closing all the switches, isolators, breakers, fuses, back feed switch etc opened earlier and puts the equipment in service.

Notations to be made

The issue of permit to work, nature of repair carried out, transfers, if any, cancellation of permit should be noted in the Log Book maintained by the permit issuing department.

7.5 Acid Area Work Permit

Acid being highly corrosive and the gases generated during their process are obnoxious, harmful and some times explosive. Maintenance and repair work in an acid manufacturing and processing plant can contain numerous hazardous conditions. Therefore, to control over such works through a permit system helps to a great extent in reducing accidents. Before a work permit is issued to authorize work on acid lines or equipments handling acids and acid gases, the person in-charge of the plant makes a thorough study of the work and the hazards involved. Taking adequate safety precaution for isolation, depressurization, draining, washing, flushing, purging, fire prevention etc., he issues a permit, with special instruction for use of protective equipments.

On receiving the permit, the person in-charge of repair crew makes a counter check that the equipment handed over for repair work has in fact, been isolated, depressurized, drained, washed, purged made adequately safe for carrying out the repair work. He should also ensure that the men working under him use the personal protective equipments prescribed on the permit, before commencing the job.

7.6 Safe work Permit or Work at Height Permit

Many accidents are caused due to falls while working at heights and roof tops. Most of the accidents result in fatalities or very severe injuries. This phenomena is more acute in construction industries. Therefore, to put a curb on the rising trend of fall accidents it was felt necessary to bring about certain controls over such works and provide adequate safe guards for the people working at higher elevations.

Consequent to the necessity, the Government of Andhra Pradesh made it mandatory vide Rule 61-D of Andhra Pradesh Factory Rules, 1950 that, in the event of any person required to stand, pass over or work on or bear any roof of ceiling covered with fragile material or required to work at an elevation of more than 3 meters height, adequate safety measures should be proved to prevent falls. For the purpose the rule suggested the provision of ladders, duck ladders, crawling board and use of safety belt etc. The rule also stipulates that each time a person is required to work on the fragile roofs or at higher elevations, the job shall be carried out under the authority of a work permit issued by a responsible person of the factory.

7.7 Multiple Permit

Since most of the work permits contain same or similar contents, industries tend to use one single permit form with different headings for various works by striking out the irrelevant headings. But, it has been experienced that the procedure had created confusion and misunderstandings and resulted in accidents. Therefore, it is desirable that different format are used for different work permits rather than using one single format with different heading.

8. Conclusion

Permit system in an industry plays an important role in minimizing accidents occurrences, in that it helps the industry and the people concerned to convert a known hazardous work situation into a safe work environment. But the success of the system will greatly depend upon the understanding and strict compliance by all concerned.

5.3 SAFETY IN START-UP AND SHUT DOWN PROCEDURE

1. INTRODUCTION

The operating procedures are normally formulated during the plant design and are modified as necessary during the plant commissioning and operation. Different company has different instructions documents. Operators should have sufficient information to operate their task in normal & emergency situations but not so much about related matters that they become confused.

Procedure required to be adopted for start up and shut down of the plant under both normal and emergency situation need to be prepared as Standard Operating Procedure (SOP) for the specific purpose. SOPs are useful for start-up and shut-down of the following activities:

- Procedure for plant start-up
  - : Initial start-up
  - : Start-up of plant section when rest of plant down.
  - : Start-up of plant section when other plant on stream
  - : Start-up after maintenance
  - : Start-up after emergency shutdown
  - : Lighting of furnace/flare

- Different modes of shutdown
  - : normal shutdown
  - : Partial shutdown
  - : Emergency shutdown
  - : Manual control/remote control identification process

- instruction for deviation in process parameters

- Procedure for product quality, handling of materials, effective use of energy.

- Procedure to control omissions of effluents & their treatment

- Procedure for recycling of intermediate streams/regeneration of beds/catalyst etc.

- Operating procedure of each unit/equipment giving how it is to be operated with design condition.

2. START-UP PROCEDURE

The start-up & shutdown of plant must proceed safety & easily & should be flexible enough to be carried out in several ways. The operating limits of the plant must not be exceeded and dangerous mixtures must not be formed as a result of abnormal states of concentration, pressure, temperature, phase, reactants, catalyst and product. Control system must not operate out of their normal range, Mechanical, electrical, instrumentation faults may also appear during start-up.

2.1 Typical Errors on Start-up of Plant

- Wrong routing, involving failure to ensure that correct valves are opened and all other valves are closed.
- Drain valves left open, resulting in release of material.
- Errors of sequence (the personnel involved; in the start-up should understand the reasons for the sequence chosen & should adhere to it.)
- Valves left closed & over pressurizing the system.
- Failure to complete the purging cycle before admission of fuel air mixture.
- Mixing cold & hot layers with consequent excessive vaporisation.
- Admission of steam into cold line full of condensate, resulting in water hammer.
- Backflow of material from high pressure to low pressure system.
- Setting wrong valves for operating parameters
- entry of unwanted material like, air, water etc.

2.2 Phases of Start-up

In order to have effective start-up procedure should be divided into phases:

i) Preparatory Activity

: Inspect & check for initial start-up
: Activate utilities, instruments etc.
: Removal of shutdown blinds & installation of running blind.

ii) Removal of Air

: Purging by suitable media
: Analyse for oxygen content
: Maintain record of Test

iii) Leak Testing

: Close all vents & drains
: Raise equipment pressure for leak testing
: Inspect & check all joints, connections for leakage.
: Disposal of purge material & removal of water if any.

iv) Bringing on Stream

: Adjust Main parameters gradually

v) Providing Safety Instruction for Operator

: First immediate action on detecting an abnormal state.
: First immediate response to an alarm signal.
: General safety instruction for the job (hazards & Precautions)
: Detailed safety instructions for hazardous tasks
: Special emergency instructions.

2.3 Start-up After Emergency Shut Down

: Provision of Recycle Loops.
: Examine whole process carefully in order to establish possible events.
: Provide measure for them.

3. SHUT-DOWN PROCEDURE

3.1 Normal Shutdown

A normal shutdown may be an occasion for disposal or inactivation of residues, so the shutdown of plant should include following phases:

i) Cooling & Depressurizing

: Stop heat input
: Reduce /stop Feed
: Release excess pressure
: Full cooling (If cooling cause under pressure, introduce inert gas to maintain pressure close to atmospheric)
: Transfer of material to another vessel.

ii) Pumping Out

: Pumping out by centrifugal pump should not loose suction completely & not allow to run dry even for short period.
: Maintain pressure in unit by admitting inert gas.

iii) Removal Of Residues

: Purging with steam, water, inert gas
: Flood with diluents
: Add neutralizer
: Vent to scrubber
: Stop mixing
: Avoid freezing of water in system.

iv) **Blinding Activities**:

: Installation of shutdown blinds
: Removal of running blinds.

v) **Removal Of Pyrophoric Material (Iron Sulphide)**

3.2 Emergency Shut-Down

In case of emergency, the plant must return to safe condition by the operation of emergency shutdown system or special plant process trip system on pressing push button by operator or form automatic activation of relay. The shut down system should be designed to partition the plant into different segments. Alarms can indicate which trip has been activated or warn about the imminent danger of plant. Emergency power supply must be considered in conjunction with shutdown system for such equipment as is critical to the plants safe operation during shutdown. The actions to be taken by the operator on failure of any item or sounding of an alarms must be clearly given in such manual. The consequences of a wrong action or of no action on failure of an item should also be considered.

4. IMPORTANT RECOMMENDATIONS FOR STANDARD OPERATING PROCEDURES

On the basis of safety studies, the following recommendations are given for consideration :

It is observed that the procedures are written in abstract manner and create confusion. Hence is desirable to make extensive use of checklist in remembering all operational steps.

During shutdown & start-up, special care must be taken to see that all lock out procedures are followed closely for electrical works, moving machinery and valves. This should be specifically mentioned in the operating manuals.

Process operators and other personnel should be thoroughly trained in the operating procedures.

Layout plan indicating location of manual control, remote control and emergency control must be provided in such manuals.

Written & operating procedures should be available at different units of an installation.

Written procedures must be rehearsed. Kept upto date and kept available to people that have to use them.

The management of company must ensure for quality, completeness and correctness of all the statements made in it.

Hazard and operability study, (HAZOP) should be carried out to all manual operating situations such as start-up, operating and shutdown.

5.4 COLOUR CODING OF PIPELINES AND CYLINDERS

5.4.1 COLOUR CODING ON PIPELINES

INTRODUCTION

Lack of uniformity of colour coding of pipe lines in industrial installations has often been responsible for destruction of property and injury to personnel. It happens due to faulty manipulations of valves, particularly when outside agencies like fire fighting squads, members from other factories as a member mutual aid scheme are called in. Uniformity of colour marking promotes greater safety, lesser the chances of error and warns against the hazards involved in the handling of material inside the pipe lines.

Identification of the particular contents of the pipe lines is achieved by imposing suitable colour bands on the ground colour. Lettering as a mode of identification is also recommended for chemical industry as this will reduce the possibility of mistakes in identification. Lettering may include the contents by name, chemical formula or by unmistakable and commonly understood abbreviations.

Indian Standard IS 2379-1990 covers the colour scheme for the identification of the contents of pipe lines carrying fluids in domestic and public buildings and industrial installation. The purpose of this standard is for piping system which include pipes of any kind and in addition fittings, valves and pipe covering. The standard is not applicable to pipe lines buried underground or used for electrical service. In order to identify the contents of the pipe lines a large number of colour shades are used.

IDENTIFICATION

The system of colour coding consist of a ground colour and colour bands superimposed on it.

(A) Ground Colours

The ground colour identifies basic nature of the fluid carried and also distinguishes one fluid from another. Various ground colours are indicated in Table-1.

Table – 1
Ground Colour

Substances	Colour
Water	Sea Green
Stream	Silver Grey
Mineral, vegetable and animals oil, Combustible liquids	Light Brown
Acids and Alkalies	Dark Violet
Air	Sky Blue
Other liquids	Black
Gases	Canary Yellow

(B) Colour Bands

Colour bands are superimpose on ground colours to distinguish – (a) one kind or condition of a fluid from another kind or condition of the same fluid; or (b) one fluid from another but belonging to the same group for example carbon monoxide from coke over gas.

APPLICATION

Ground colour shall be applied throughout the entire length for un-insulated pipes for insulated pipes on the metal cladding or on the pipes of material such as non-ferrous metals, austenitic stainless steel, Plastic, etc. Ground colour coating of minimum 2 meter length or of adequate length not to be mistaken as colour band, shall be applied. Wherever ground colour is not applied throughout the entire length, it shall be applied near valves, junction, joints, service appliances bulk heads, walls, etc.

When colour bands are superimposed on the ground colour, the ground colour shall extend sufficiently on both sides of colour bands to avoid confusion. Colour Bands shall be superimposed on ground colour at the following location :

(a) At battery limit points
(b) Intersection points and change of direction point in piping ways
(c) Other points such as midway of each piping way, near valves, junction joints of service appliances, walls on either side of pipe culvert.
(d) For long stretch year piping at 50m interval.
(e) At start and terminating points

Valves shall be painted with the same colour as the main pipe lines except when the pipe lines have been provided with the safety colour. In that case valve shall be painted red for fire fighting yellow with black diagonal stripes for warning of dangers and French blue in conjunction with the green basic colour to denote pipes carrying fresh water either potable or non-potable. All un-insulated pipes having temperature above 100℃ (Heat resistance Aluminium painted) need not to be identified with colour band. As a special case, if required colour bands may be applied using Teflon tape. When it is desired to indicate that a pipe line carries a hazardous material, a panel of colour of suitable width (minimum 100 mm) as given below shall be superimposed on the ground colour at suitable intervals:

a) Slightly Radio-active hazards – A base colour of Jasmine yellow with black dots suitably superimposed

b) Highly Radio-active Hazards – A base colour of light orange with cross diagonal strips of black colour suitably superimposed.

c) Other Hazards – Equal diagonal strips of black and golden yellow colours. Different legends for various types of hazards other than radio activity like that for flammable or explosive material, chemically active or toxic material, etc. may be indicated by lettering.

ADDITIONAL IDENTIFICATION

When further identification is required to supplement the colour code, this may be done by the particular industry for its own use.

Lettering

Lettering is recommended for chemical industries for the products not covered in this standard. For steam, temperature and pressure shall be indicated after colour indication by lettering.

Direction of Flow

Where it is required to indicate the direction of flow, arrows and letters may be painted near valves, junctions, walls etc. and at suitable intervals along the pipe in a manner best suited to local condition. These shall be black or white in colour and in contrast to colour on which they are superimposed. For central heating system or other closed circuits where it is necessary to indicate separately the flow and return pipes, this shall be done by the use of the word FLOW or the letter F on one pipe and RETURN letter R on the other pipe.

VISIBILITY OF MARKINGS

Attention shall be given to the visibility of colour marking and lettering, where the pipelines are located above the normal like of vision of the operator, the lettering shall be placed below the horizontal line.

5.4.2 COLOUR CODING ON CYLINDERS

Identification of any cylinder filled with compressed gas for the purpose of storing and despatching is given in the Gas Cylinder Rules, 2004. As per Rule 8 of the said Rules, every person filling any cylinder with any compressed gas shall before it is stored or despatched, see that the cylinder is painted with appropriate identification colours specified in IS : 4379 for industrial cylinders and IS:3933 for medical cylinders. No person shall, in any way, interfere with or change the colour painted on a gas cylinder.

Cylinders used for new gases and gas mixtures for which identification colours are not provided in the aforesaid Indian Standards, shall be painted with the colours indicated in the following table:

Name of the Gas contained in the Cylinder	Colour of the Cylinder shall	Colour Band at neck end of the Cylinder
Non-flammable and non-toxic	White	-
Non-flammable but toxic	White	Yellow (IS Standard Colour No. 356)
Flammable but non-toxic other than LPG	White	Red (IS Standard Colour No. 537)
Flammable and toxic	White	Red and Yellow (IS Standard Colour Nos. 537 & 356)

ADDITIONAL IDENTIFICATION

Every cylinder shall be labelled with the name of the gas and the name and address of the person by whom the cylinder has been filled with gas. A warning in the following terms shall be attached to every cylinder containing permanent or liquefiable gas, namely –

"WARNING"

i) Do not change the colour of this cylinder
ii) This cylinder shall not be filled with any gas other than the one it now contains.
iii) No flammable material shall be stored in the immediate vicinity of this cylinder or in the same room in which it is kept.
iv) No oil or similar lubricant should be used on the valves or other fittings of this cylinder.
(i) Please look for the next date of test, which is marked on a metal ring inserted between the valve and the neck of the cylinder, and if this date is over, do not accept the cylinder.

5.5 INSTRUMENTATION FOR SAFE OPERATING PLANT PROCEDURES (SOPs)

1. Safe Operation Procedure

"Operating procedure tells us how a plant is to be operated safely within design parameters and deviations from normal operating condition." Unsafe operating procedures in industries often result into accidents. Opportunities for hazard arise whenever process conditions are changed. The frequency of such changes may be reduced by building in process reliability and stable operating conditions. All possible activities other than normal operation must be identified and safe procedure must be developed and established and documented after thorough investigation of process dynamics. The operator spends his most of the time in control room and patrolling the plant so as to observe any abnormalities and to deal with plant upsets. Therefore, plant operators should have manual of normal and immediate alarm procedures and should know which abnormal conditions require action and by whom. Working Alarm procedure and the Control System operated in the control room is solely dependent on instrumentation for safe operating plant procedure.

2. Instrumentation Vs Safe Operating

Operation of any plant according to specified conditions is an important aspects of loss prevention programme. Beside loss prevention, maintaining the operating condition normal is also an essential features for quality product and optimization of the product. Thus control system, which includes both process instrument and process operator, have a crucial part to play for efficient running of plant. Hence, for loss control and productivity, an effective control system should be designed and maintained. For designing a control system, it is essential to define the objective of the system. Once objectives are defined, the function of subsystem also can be specified. Typical subsystems are those concerned with instrumentation which deals with measurement, alarm, detection, loop control, trip action, etc. The next step is the allocation of function between the instrumentation and operator.

3. Basic Control System

The main control systems considered here are of analogue type employing continuous feed back and are based either on pneumatic signals in the pressure range 0.2 -1.0 bar or d.c. electronic signals in the current range 4-20 mA. The various control modes and other features considered here apply to both pneumatic and electronic systems despite their other differences. Pneumatic systems employ small mechanical devices with moving parts. Electronic system use electronic amplifiers, switches and relays. Pneumatic signals interface directly with mechanical control device. Electronic signals generally interface via pneumatics with mechanical control devices.

4. Instrument Loops and Degrees of Freedom

The feed back control loop is basic to process control. It includes the process, the measuring element, the controllers which receives its signal from measuring element and the final control element which manipulates a process variable as it receives signals from the controllers. It is a closed loop when controlling automatically but an open loop when the control element is actuated manually (some authors refers the loop as closed when the human operates the control valve). Most controllers have an adjustable set point which can be set at the required value of the variable under control and they measure the deviation between the set point and the measured value of the variable. Their signal to the final control element aims at correcting any deviations which may result from process disturbances (known as upsets). This may occur when steady conditions are re-established and depending on the control mode, the deviation will have been eliminated or a residual deviation known as the offset will remain.

With fee back systems and their components, there is a time lag referred to as a 'dead time' between any stimulus and the response of the system or component to it. This sometimes causes serious problems. The number of closed control loops needed for any process equals the number of independent variables or degrees of freedom (e.g. Temperature, pressure, flow rate, concentration) which have to be controlled. But if too many control loops are provided, they will fight each other for control and system will not work. This can happen because some variables was mistakenly thought to be independent whereas it was in fact dependent on and uniquely determined by other variables.

5. Functions of the Control System

The control system has to perform following functions

(a) Information collection;
(b) Analysis of information
(c) Normal control; and
(d) Fault administration

6. Component Features of Control System

1) Control Room
2) Measurement, sensing instrument of process variables,
3) Signal and power transmission system,
4) Receiver i.e. indicators, recorders, controllers and alarms, etc.
5) Final control elements,
6) Transmission system

6.1 Control Room

Most process plants have control room as their nerve centre. This typically houses a control desk or console with visual display unit (VDU). One or more control panels, operating personnel, sometimes a computer. On the panel is mounted a network of receiving instruments (known as receivers) which receives information from the plants. These receivers increasingly tend to incorporate PES (programmable Electric Systems) devices which extend their functions and allow plant data to be displayed on VDU built into the console instead of a panel mounted instruments. Receivers continuously receive pneumatic or low voltage electric signals to variable such as temperature pressures and are transmitted by the measuring instrument in the plants or else where. From the control room pneumatic or electrical signals are automatically sent to valves, motors etc. to control the variable as required. No hazardous materials should be allowed to enter in the control room via pipes or tubes to reach the instruments.

Control rooms are usually located close enough to their plants for operators to be able to move quickly from the control room to inspect plant item or open and close valves etc. Good communications are also essential between those working in the control room and those on the plants. Factor that affect operator morale and instrument performance such as temperature, humidity, air movement, noise, vibration, illumination interior decoration and furniture in a control room should be considered. In the plants where hazardous (flammable, toxic, explosive) gases vapours and dust are present, control room may have to be located in the area classed as hazardous area and control room personnel may have to work inside during emergency situation. For safety of the operating personnel and the system, control room should be designed as separate blast resistant single story buildings. Windows if fitted should contain only small panel of toughened glass control rooms should be pressurized and admittance through a air lock with self closing doors which allow a slight positive air pressure to be maintained inside it. Air supplied for creating positive pressure should be from non-hazardous area. So that air supplied should not have hazardous substance as contaminants.

6.2 Measuring Instruments and Sensing Device for Process Variables

Process variable include physical variables temperature, pressure, flow and level physical properties such as density, viscosity, thermal conductivity, refractive index, calorific values and Wobbe Index of fuel gases, vapour pressure boiling points and chemical composition. Each of these can be measured by several different methods, the choice of which needs careful studies. Important considerations include, simplicity, speed of response, accuracy , reliability the consequences of failure, cost standardization, familiarity by the operating organization, ease of installation and servicing. More problem may cause by faulty installation, servicing and by inappropriate choice of instrument than by failure of instruments themselves.

Clear thinking is needed about what should be measured and how this relates to other measurements. One should consider the principle of the meter and whether its measures the required variable directly or whether measures certain related variables and converts its. This some thermometers measures the vapour pressures of the liquid and converts this to a linear temperature scale whereas the vapour pressure itself may be a better control parameters then temperature. Some flow meters measures volume flow, some measures mass flow, while variable head and variable area meters measures volume flow divided by square root of fluid density. If the fluid density is liable to change and the figure required is either a volume flow or mass flow, a continuous density meter and a computing device would be needed as well if a variable head or a variable area meter were used.

6.2.1 Temperature Measurement

Thermocouples and electric resistance thermometers are commonly used for direct intrinsically safe cable transmission to receivers. Instruments with fluid filled bulbs and bimetallic strips used for local temperature measurement are simple and generally reliable. Fluid filled bulbs with long flexible metal capillary tubes (which are easily damaged) are used for remote control and recording usually on small plants with little instrumentation. Radiation pyrometers of various types are used for measuring temperature of hot visible objects.

Thermocouples generate a small e.m.f. between the working junction of plant and cold junction on the receiver. The receiver includes a device which compensates for variations in the cold junction temperature. Several combination of thermocouples available from -250° to 2600℃. The combination must suite to the corrosivity and temperature ranges of its working environment only couples whose e.m.f. increases continuously with the temperature differences between cold and hot junction over its working range can be used. A failure in the thermocouples circuit caused by breakage of welded hot junction causes drop in e.m.f. which results in lower apparent temperature than the real one. Thus it fails in the unsafe mode.

Since most thermocouples are fragile and liable to chemical attack, their working junction is generally enclosed in metal sheath or inserted in a thermo well on the plant or both. This reduces the speed and accuracy of the measurement, particularly of gas temperatures. A bare hot junction may take few second to reach thermal equilibrium but may take few minutes to do so in thermo well. Platinum resistance thermometers are available for temperature range 15° to 800℃ and nickel ones for the range - 200° to 350℃. Their resistance increases with temperatures so that any failure of the resistance circuit gives too high a temperature reading and their failure mode is safe.

6.2.2 Pressure Measurement

Pressures are measured as absolute, relative to a perfect vacuum or an gauge, relative to surrounding atmosphere while devices measuring gauge pressure are simpler than those measuring absolute pressure, gauge pressure are often converted to and quoted to absolute pressure. There are three main types of pressure measuring devices: those based on the distortion of elastic element, electrical sensing devices and manometers.

All pressure measuring devices except manometers need regular checking and calibration, generally against a dead weight tester. Their performance varies widely, not only as a result of their basic design and materials of construction bur also because of their service conditions. Care should be taken to ensure that the element can withstand maximum possible process pressure. Errors can arise from corrosion, changes in temperatures, friction, backlash and pulsations. An isolating valve is generally needed between pressure measuring device and the process. Elements should not be mounted where they are subject to vibration or extreme of temperature pulsation in process pressure should be damped by a restriction between and the measuring device.

6.2.3 Flow Measurement

The main classes of flow measuring devices used in the process industries are variable head, variable area, positive displacement, turbine, electronic flow and mass flow meters. Variable head and variable area devices are commonly used for clean liquids of low viscosity and gases flowing in pipes. Corrections have to be applied for changes in fluid density and sometimes viscosity. For this reason the gas density needs to be controlled at the constriction producing the different head, while only small temperature changes can be tolerated at this point. Orifice plates are the most commonly used form of restriction while venturi and dall tubes have lower energy losses. Errors arise through deposits of solids on either side of the restriction and through the presence of gas or second liquid phase in the lines between the pressure tapings and the differential pressure cell.

The most common form of variable area meter is the rotameter - a tapered vertical tube with a linear scale and a plumb bob spinner (with a higher density than the fluid) which moves up and down the tube as the flow increases and decreases. Transparent glass tubes are used for local metering of small flows and metal tubes with electromagnetic sensing of the position of the spinner are used for larger flows and dangerous fluids and allows easy signal transmission. Several types of positive displacement meter are used to give the total volume of fluid which has flowed for specific period. They are mostly rotary type of high accuracy and are little affected by pulsations in flow and by changes in fluid density or viscosity. They are mainly used for accounting purposes and dispensing known quantities of liquids and not for flow control. A turbine meter consist of a tube with an axially mounted turbine wheel rotating between almost frictionless bearings. The rotational speed of the wheel is proportional to the volumetric flow rate and is sensed by an electric pick up coil outside the tube. It can be used as the measuring element in flow control loop as well as for accounting purpose.

Several types of electronic flow meters have been developed over the past two decades of these electromagnetic flow meters have special uses, being able to measure dirty liquids, slurries and pastes provided these have an electrical resistivity greater than 1 micro ohm/cm. Their accuracy is largely unaffected by changes in temperature, viscosity, density or conductivity. Ultrasonic flow meters based on Doppler effect and on the transmission of an ultrasonic pulse through the flow stream also have considerable promise as do those leased on the frequency of vortex shedding from a bluff body in the flow stream.

Mass flow meters are of two types : True mass flow meters which measures the mass flow directly and inferential mass flow meters which measures both a combined function of the mass flow and density itself and compute the mass flow from two measurements.

6.2.4 Level Measurement

There are two circumstances with rather different requirements where levels are measured sensed:

Storage of liquids and particulate solids including the feed and product tanks of process. Here accurate measurement is needed for accounting purposes. For control of liquid levels (including liquid/liquid interfaces) in vessels of continuous processes. In this both cases high and low level alarms and sometimes trips are often need to prevent accidents. Methods of liquid level measurement include dipstick and tapes, gauge glasses, float actuated devices, displacer devices, head devices and electrical devices based on electrical conductivity and dielectric constant Radio active level gauges are used to some extent for measuring depth of solids in silos.

6.3 Signal and Power Transmission System

Most instrument systems rely on pneumatic or electrical power for signal transmission and control and electricity for chart drive and illumination. Pneumatic systems should create no ignition risk in electrically hazardous areas, where pneumatic valve actuators are generally cheaper and simpler than electric ones. Pneumatic signal transmission is however, relatively slow, thus limiting transmission distance to about 100 m. Low d.c. intrinsically safe electrical current signal transmission and electronic instruments in the control room are often combined with pneumatic valve actuation.

All instrument power sources must be completely reliable. While failures of plant electrical power, steam, fuel gas and water usually cause en emergency shut down, sudden and complete loss of control instrumentation is even more serious, since without it, it is far more difficult to shut down the plant safely particularly if one of the other services fails at the same time. On a large or medium sized works, a reliable supply of clean, dry, compressed air is conveniently provided by an electrically driven air compressor with a diesel driven stand by compressor and a large compressed air reservoir capable of meeting all likely demands until the stand by unit is operating in the event of electrical failure instrument air should be distributed by a ring main to give two alternative supply routes to every plant.

A reliable supply of high quality electrical power, with emergency supply to critical instruments from batteries and/or a stand by generator is needed for electronic instrumentation. The instrument circuits should be kept entirely separate from the normal power and lighting circuits and must meet the relevant flame proofing or intrinsically safe requirement.

6.4 Receivers

Instruments on a control panel should be arranged logically for the operator and most critical instruments should be well within a his or her field of view enlarged flow sheets on the control panel with colour coded lines and lights to show the condition of the process can greatly assist operation. The accuracy of instrument reading should be appropriate to the need. Errors are less likely with digital displays than with pointers and dials the latter are better for rough checking and for assessing rate of change. The best arrangement for reading accuracy is moving dial with fixed pointer. The nest best is circular of semicircular scale with moving pointer. Horizontal and vertical scales are most prone to reading errors. Instruments should react quick enough to show expected movements and be sensitive enough to show the smallest meaningful change in the variable measurement where readings of several dials to be checked e.g. the temperatures or flow of several parallel streams, all pointers should point in the same direction for the same plant condition. Identical instruments and scales should be used for identical duties on parallel processes.

Control should be grouped according to their function and to the part of the plant which they affect. Those which have to be operated at sequences should be placed near each other and if possible in their order of operation even though this leads to an asymmetrical layout. Different types of control knobs should be used for different function.

Alarms and Trips

All critical points of operation in a plant are normally protected by alarms and/or shut down devices which are actuated by micro switches triggered by high or low pressures, flows, levels, temperatures, etc. An audible/visual alarm is actuated when the variable deviates from normal and reaches a certain figure, to allow the operators to take corrective action. If this is unsuccessful and the variable deviates further to reach to an another figures, a shut down may be actuated, which by means of a solenoid valves in appropriate instrument air lines shuts down one or more section of plants. The alarms consists of a horn or other audible device and lights. All warning light continue to show until the variable which set them off have returned to their normal range. When some mal function, perhaps of an instrument, develops suddenly on highly interactive plant, it generally actuates an alarm for a particular part of the plant. It is then often surprisingly difficult to pin point the source of the mal function and distinguish between cause and effect. To avert complete plant shut downs because of minor mal functions, the panel instruments should allow operators to take some holding action, such as putting the plant on total recycle or columns on total reflex, while the problem is being investigated.

6.5 Final Control Elements

The final control device consist of two parts, an actuator and a valve or other mechanism (such as a variable output pump) which adjust a flow or other manipulated variable. The actuator translates a signal, usually, pneumatic, electric or hydraulic into a force which operates the valve, etc. with pneumatic actuators the air pressure acts on a diaphragm attached to a stem and is opposed by a spring. Two versions are available, one which opens and other which closes the valve with increasing pressure. Ideally the actuator should respond quickly and assume a position proportional to the signal pressure. In practice the action may be sluggish and position reached may deviate from linearity. The delay is caused by the time taken for sufficient air to travel through the transmission tube to pressurize and enlarge the space behind the diagram in order to move it. This delay increased with the volume of the diaphragm chamber and length of the transmission line lack of linearity may be caused by the force of the process fluid on the value plug and friction in the valve gland.

To overcome these problems valve positioner and signal boosters are often used. The pneumatic valve positioner uses a separate air supply to operate the valve and adjust its position to correspond exactly to the signal pressure.

Direct current electrical signals are generally converted to a variable air pressures by electro-pneumatic transducer mounted on the control device. A typical electro-Pneumatic actuator is a combination of current to pressure transducer. A feed back positioner and a pneumatic spring diaphragm actuator. Hydraulic actuators employ a fluid acting on one or both sides of a position. In the first case the force of the fluid is opposed by a spring and the operation is similar to a pneumatic actuator. Purely electrical actuators are also used in which an electric motor or solenoid provides the driving force. These can easily be used to open or close a valve completely but those which adjust their position to correspond to an electrical signal are more complicated.

5.6 PERSONAL HYGIENE (AND HEALTH AWARENESS)

1. PERSONAL HYGIENE

The word "Hygiene" is derived from "Hygeia", the goddess of health in Greek mythology. Hygiene is defined as "the science & art of health and embraces all factors which contribute to healthful living". This has two aspects - Personal & Environmental. The aim of personal hygiene is to promote standard of personal cleanliness within the setting of the condition where people live. Personal hygiene includes bathing, clothing, washing hands, toilet, care of feet, hands, nails, teeth, spitting, coughing, sneezing, house keeping, smoking, eating etc.

Improvement of Environmental health is a major concern of many Industries. The objective of health education in environmental health promotion through improvement of personal hygiene are :

1. to educate the people in the principle of environmental health with a view to bring about desired changes in health practice.

2. to secure adoption, wide use and maintenance of environmental health practice.

3. to promote active participation of the people to improve the personal & environmental health.

2. HEALTH AWARENESS

Health awareness is a process that brings out changes in workers' Knowledge, Attitude, Skill & Behavior. It helps a worker :

(a) recognize a problem; (b) analyse it; (c) set a realistic goal

The health awareness comes mainly through (a) Health Education & (b) Training

3. Health Education : It aims at (a) encouraging workers to be healthy; (b) knowing how to stay healthy through scientific information

Health Education steps to :

(a) culture a health awareness;
(b) culture a healthy lifestyle;
(c) culture a group responsibility;
(d) culture interest, attitude & value;

Practice of health education has two main aspects, viz

(a) Individual Health education
(b) Group health education and group health education is achieved through :
- (a) Lecture
- (b) Group discussion
- (c) Panel discussion
- (d) Symposium
- (e) Workshop
- (f) Institute
- (g) Role playing

(h) Demonstration
(i) Programme instruction
(j) Simulation exercise

Health education in general is achieved through :

(a) Radio
(b) T.V.
(c) Film
(d) Press
(e) Health magazines
(f) Posters & display
(g) Health exhibition
(h) Health museums

Training

Workers often experience work related health problems and do not realize that the problems are related to their work, particularly when an occupational disease, for example, is in the early stage. Besides the other more obvious benefits of training are :

(a) Skill development
(b) Hazards recognition

A comprehensive training programme in each workplace will help workers to :

(a) recognize early stage/symptom of any potential occupational diseases, before they become permanent.
(b) assess their work environment
(c) insist the management to make changes before hazardous condition can develop.

Employee training should be designed to influence employees to comply with appropriate work practice. Such training should be conducted periodically for all employees. Training should include the following areas :

(a) Potential risk of over-exposure;
(b) The importance of industrial hygiene & biological monitoring and notification of test results;
(c) Description of work practice control including personal protective equipment,

first-aid and emergency training.

5.7 CHEMICAL SAFETY DATA SHEET

The occupier of every factory carrying on a "hazardous process" shall arrange to obtain or develop information in the form of Safety Data Sheet in respect of every hazardous chemical substance handled, manufactured or transported in the factory. The information should be accessible upon request to a worker for reference. As per Rule 17(2) of the MSIHC Rule 1989, an occupier who has a control of an industrial activity in which a hazardous chemical which satisfy any of the criteria laid down in part I of Schedule 1 and listed in column 2 of part II of Schedule 1 shall arrange to obtain or develop information in the form of safety data sheet. The information shall be accessible upon request for reference.

Every such Safety Data Sheet of hazardous chemical should reveal potential hazards of the chemical, safe practices and engineering control to minimize / control the hazards. The data sheet shall include the following information, namely:

- i) the chemical identity used on the label, chemical name with classification (UN No., Hachem No., CAS No.)
- ii) hazardous ingredient of the substance
- iii) physical and chemical characteristics of the hazardous substance
- iv) physical hazards of the hazardous substance, including the potential for fire, explosion and reactivity
- v) health hazards of the hazardous substance, including signs and symptoms of exposure and any medical conditions which are generally recognized as being aggravated by the exposure to the substance
- vi) the primary route(s) of entry
- vii) the permissible limits of exposure prescribed in the Second Schedule under section 41-F of the Factories Act 1948
- viii) Emergency and First Aid Measures
- ix) Manufacturer/Supplier Data

The occupier while obtaining or developing a Chemical Safety Data Sheet in respect of a hazardous chemical shall ensure that the information recorded accurately reflects the scientific evidence used in making the hazard determination. If he becomes newly aware of any significant information regarding the hazards of a substance, or ways to protect against the hazards, this new information shall be added to the Chemical Safety Data Sheet as soon as practicable.

5.8 HOUSEKEEPING

1. INTRODUCTION

Housekeeping means cleanliness and orderliness. A good housekeeping means a place of everything and everything in its place. Poor housekeeping is a source of accidents in industry.

Poor House Keeping

A poor housekeeping means existence of unsafe condition at work place which may cause accident. Examples of poor housekeeping are given below:

1. Floor with loose articles, nails, oil, grease, ditch/pit, uncovered manhole, broken uneven etc.

2. Work place, work bench, wall, ceiling, door window-full of dust, dirt or unwanted things hanging or lying giving a shabby look.

3. Non-disposal of sward, scrap, effluent and waste from the work place.

4. Non-extraction of air pollutants like dust, fume, smoke, gases, vapour, mist, etc. from the work environment.

5. Improper lighting causing low level of illumination or shadow, uneven distribution of luminous flux, production of glare / shadow.

6. Inadequate ventilation causing discomfort in the work place in terms of temperature, humidity, air movement, air changes, etc.

7. Non-provision or blocking approaches to emergency equipment (fire bucket, portable fire extinguisher, fire call point, fire hydrant, first aid box, emergency shower, stretcher room etc.).

8. Keeping or stacking materials, equipment, tools etc. at such a position as to hinder easy and safe movement of men and materials or stack may collapse by slight disturbance.

Housekeeping vs. Safety

A good housekeeping takes care of all the shortcomings mentioned above and make a work place reasonably conducive, safe and comfortable. Workers find it easy and less tiring job to complete their assigned tasks successfully and safely. If the floor, wall, door, window, ceiling, work bench etc. are carefully maintained out of dirt, dust, unwanted things, illumination and ventilation are properly maintained, storage of materials are paid due attention and emergency equipment are promptly available when needed, it may be ascertained that housekeeping will play a vital role in achieving safety in industry.

A good standard of housekeeping may be maintained if we follow the DO's and DONT's given below:

DO's

1. Keep your surroundings clean to the extent possible.

2. Maintain floor free from cracks, pit holes, unevenness, loose articles, nails, sharp objects, oil grease, chemicals, scraps, waste/end pieces, etc.

3. Ensure your work bench/table free from unwanted things.

4. Keep tools, accessories, attachments, and other essential devices/aids at the respective place after use.

5. Dispose off swarf and waste at a periodic period interval of time; use covered waste bins for the purpose.

6. Ensure extraction of dust, fume, gas, vapours, mist from your work area.

7. Maintain comfortable work atmosphere in respect of temperature, humidity, air movement, air changes, etc.

8. Store materials without blocking normal passage in the shop floor.

9. Keep oily waste in a separate bin with cover.

10. Maintain emergency equipment always in order.

11. Keep passage to emergency equipment free from obstacles.

12. Maintain proper floor marking for aisle ways, storage area inside and outside the plant.

13. Try to keep your work place with a decorative touch.

DONT's

1. Do not throw oily waste here and there.

2. Do not smoke or use naked flame in restricted area marked "NO SMOKING"

3. Do not keep loose articles/objects narrowing down common passage aisle way, gangway, etc.

4. Do not misuse fire bucket.

5. Do not allow unwanted things to accumulate at your workplace.

CONCLUSION

A good housekeeping adds grace to safety. A prudent management desirous of achieving higher productivity pays adequate attention to maintain a reasonable standard of good housekeeping.

5.9 PERSONAL PROTECTIVE EQUIPMENT (PPE)

1. LEGAL REQUIREMENTS OF PPE

Under the various provision of the Factories Act ,1948 and rules thereunder suitable personal protective equipment is required to be provided by the management.

2. REQUIREMENTS OF PERSONAL PROTECTIVE EQUIPMENT

Requirements of suitable protective equipment can be listed as under :

i) Adequate protection against the hazardous to which the worker will be exposed.
ii) Maximum comfort and minimum weight compatible with protective efficiency.
iii) No restriction of essential movements.
iv) Durability and susceptibility of maintenance on the premises where it is used.
v) Construction in accordance with accepted standards for performance and material.

3. NEED FOR PERSONAL PROTECTIVE EQUIPMENT

In industry it may be possible to substitute a dangerous substance with a safer substance, to isolate the process, to have automatic and mechanical handling of the substance or to have controlled ventilation of the process or to plan and arrange operation that personal protective devices are not necessary; but sometimes it may not be possible to introduce such measures or there might be a breakdown in the plant or in the control measure. Under such circumstances it will become necessary to use personal protective equipment. It must be borne in mind that personal protective equipment do not eliminate a hazard. These devices are designed to interpose an effective barrier between a person and harmful objects, substances or radiations.

4. TYPES OF PROTECTIVE EQUIPMENT

Personal protective equipment may be divided into tow broad groups :

i) Respiratory Protective Equipment
ii) Non-respiratory Protective Equipment

Selection of equipment to protect different parts of the body will depend upon the hazardous conditions like injuries mechanical contact, injuries chemical contact, etc.

5. RESPIRATORY PROTECTIVE EQUIPMENT

Atmospheric contaminants range from the relatively harmless substances to toxic dusts, fumes, smokes, mists, vapours and gases. Processes which present hazards of exposure to harmful substances should, if possible, be enclosed or ventilated to eliminate or minimize the hazard. If enclosure, ventilation or other engineering means of control are not possible for become very costly to apply to the degree required to ensure absolute safety, respiratory equipment should be provided to the workers exposed to possible danger. Even though engineering means of control are applied satisfactorily, a supply of appropriate protective equipment should be readily available for use, as there will be plant breakdowns and repairs may have to be carried out in contaminated environments. Respiratory protective equipment should be considered a last resort, or as stand by protection and never a substitute for effective engineering control.

6. CLASSIFICATION OF HAZARDS

Type of hazards to which a worker is exposed in the basis of selection of the right type of respiratory protective equipments. The hazards may be classified as under :

6.1 Oxygen Deficiency

Atmosphere in confined spaces such as vats, tanks, holds of the ships, etc. may contain air with oxygen content much lower than the 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 16% 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 or a safety lamp will be extinguished in such atmosphere. The respiratory protective equipment, in such conditions, should either supply normal air or oxygen to the wearer.

6.2 Gaseous Contaminants

These may be toxic or inert gases. The toxic gases may produce harmful effect even if they are present in relatively low concentration. The inert gases produce undesirable effects primarily by displacement of oxygen. The term 'gases' includes vapours of volatile substances.

i) **Gaseous Contaminants Immediately Dangerous to Life :** These contaminants are gases present in concentrations that would endanger life of a person 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 of concentration or the kind of gas is not know, all gases should be considered as 'immediately dangerous to life'.

ii) **Gaseous Contaminants not Immediately Dangerous to Life :** These contaminants are gases present in concentrations that could be breathed by a person for a short tome 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.

6.3 Particulate Contaminants (Dusts, Fumes, Smokes, Mists, Fogs)

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.

i) **Toxic particulate contaminants :** These when inhaled many 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, systematic poisoning or allergic reactions. Common contaminants in this group are antimony, arsenic, cadmium, chromic acid and chromates, lead and manganese.

ii) **Fibrosis-producing dusts :** These dusts do not pass into the blood stream but remain in the lungs and may cause pulmonary impairment. The common examples under this group are asbestos, coal, bauxite and free silica.

iii) **Nuisance Dusts :** These may dissolve and pass directly into the blood stream or may remain in the lungs neither producing local or systematic effects.

6.4 Combination of Gaseous and Particulate Contaminants

The gaseous and particulate contaminants may be entirely of different substances like carbon monoxide and oxides of nitrogen produced by blasting and the dust from the blasted material or they may be the same substances in liquid and vapour from like volatile liquids.

7. TYPES OF RESPIRATORY PROTECTIVE EQUIPMENT

Respiratory protective equipment may be classified as indicated below :

7.1 Air-line Respirator

Air line respirator essentially 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 continuous flow type or demand type.

In a continuous flow type, air is supplied continuously to the face piece helmet or hood. Exhaled air or the excess air entering the face-piece escapes to the surrounding atmosphere. Air supplied should be at least 100 ltrs of air per minute to enter the face-piece at least 170 ltrs per minute to enter the helmet or hood.

In a demand type respiratory 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 or cylinder of compressed air 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 breath escapes to the surrounding atmosphere through exhalation valve. Helmets or hoods are not used with demand type respirator.

Air-line 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. 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.

7.2 Suction hose Mask

It consists of a full face-piece connected to a large diameter flexible hose. The wearer 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 inspiratory effort of the wearer up to 30ft. length of the hose.

7.3 Pressure Hose Mask

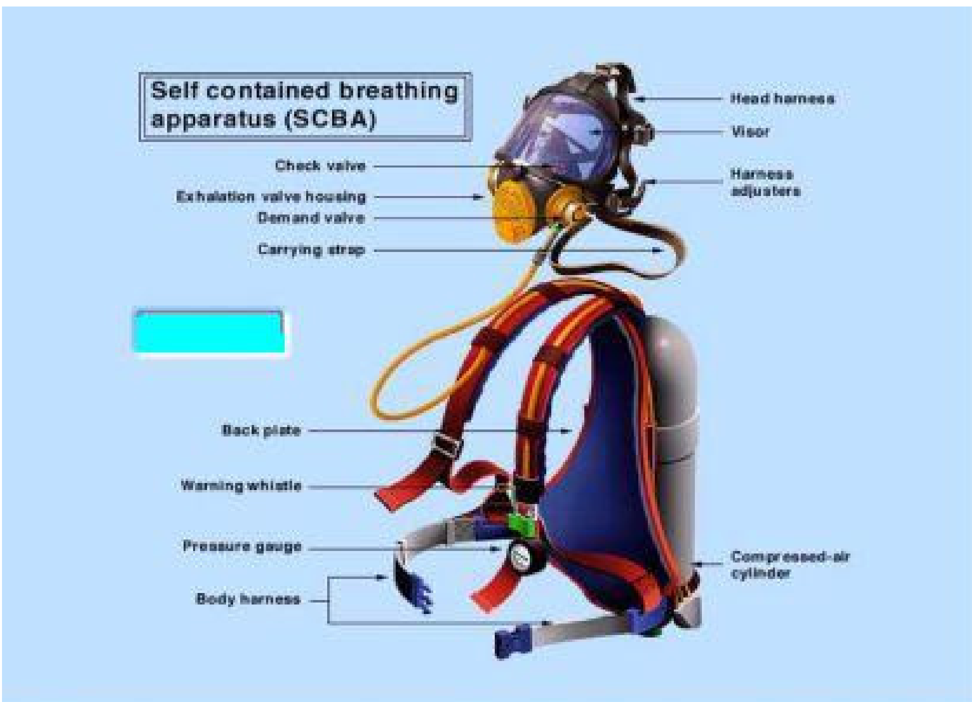
The hose mask is similar to suction hose mask except that the air is forced though a large diameter hose by a hand or motor-operated blower. The blower is to be operated continuously while the mask is in use.

7.4 Self contained Compressed air or Oxygen Breathing Apparatus

This is a device by means of which the user obtains respirable air 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 re-circulating type breathing apparatus, high pressure oxygen 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 volumes of gas in the bag have 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 amount through the unbroken skin.



7.5 Oxygen-Regenerating Re-circulating type Self-Contained Breathing apparatus

In this 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. This oxygen enters the breathing bag from which the wearer inhales through a corrugated breathing tube connecting the bag to the face-piece.

7.6 Air-Purifying Respirators

i) **Canister Gas Mask :** This consists of a canister, containing appropriate chemical, a full face-piece and body harness to told the canister in place of the body of the wearer. 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 reacted with a meutraliset. The canisters are designed for specific gases and it is very important that the appropriate type is used.

ii) The canister gas mask can only be used in atmosphere not deficient in oxygen and not containing more than 2% 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.

iii) **Chemical Cartridge Respirator :** This consists, of, usually, 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 the type of cartridge used, the connection of the gas or vapour, and the wearer's activity. It is recommended for low concentration gases and vapours (max. of 0,1.% of organic vapour)

iv) **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 consist of a small 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.

a. **Mechanical Filter Respirators :** These remove particulate matter form 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.

b. **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.

8. SELECTION OF RESPIRATOR

The following factors should be considered while selecting a respirator :

(a) Nature of the hazard
(b) Severity of the hazard
(c) Type of contaminant
(d) Concentration of the contaminant
(e) Period for which Respiratory Protection must be provided
(f) Location of the contaminated area with respect to source of respirable air,
(g) Expected activity of the wearer, and
(h) Operating characteristic and limitations of the available respirator.

9. CARE OF RESPIRATORS

Instructions in the use of Respirators, among other things, should include the following aspects:

(a) Why it is to be used
(b) How it is to be used
(c) Checking that it is in good operating condition
(d) Fitting of respirator on the wearer, and
(e) Proper use and maintenance of the respirator

10. TYPES OF NON-RESPIRATORY PROTECTIVE EQUIPMENT

Personal protective equipment for various parts of the body can be divided into five broad groups :

10.1 Head Protection

Head protectors may be hard hats and caps made of aluminium, PVC, fibre-glass, laminated plastic or vulcanized 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.

Soft caps and hoods are also used for protection against heat, spark and other dangerous materials and are made of appropriate materials. Some times hoods are made with rigid frame which is held away from the head.

10.2 Eye & Face Protection

Numerous eye injuries are caused by dusts, flying particles, splashes and harmful radiation. It is difficult to cover precisely the various processes in which the worker may be required to wear goggles. The hazards encountered may be:

Relatively large flying objects	Chipping fatling, riveting sledging, caulking etc.
Dust and small flying objects	Scaling, grinding, stone dressing, wood-working
Splashing of metals	Babbiting, pouring of lead joints, casting of metals, galvanizing and dipping in molten metals
Splashing of liquids, gases and fumes	Handling or acids and other chemicals
Reflected light, glare and radiant energy	Foundry work glass furnaces, gas welding and cutting, are welding.

Eye protectors may be safety spectacles, mono-goggles, impact goggles, welding goggles, foundry goggles, chemical goggles, gas tight goggles, face shields, welding helmets, etc.

10.3 Hand & Arm Protection

Protecting of the hands and arm becomes necessary when workers have to handle materials having sharp and sharp edges or when hot and molten metals, chemicals and corrosive substances have to be handled. The protective devices may be gauntlet gloves, wrist gloves, mittens, hand pads and thump and finger guards and sleeves. It is important not only that the various parts of arm and hand are adequately covered, but that they should be covered by a material suitable for withstanding the specific hazard involved.

Sustained heat	Asbestos, asbestos reinforced with leather, aluminised fabric.
Sparks	Asbestos, fire resistant duck, leather, glass fibre
Hot metal splash	Leather, fire resistant duck, glass fibre.
Dust	Fabric, coated fabric, plastic, natural rubber, synth.

	rubber
Chips & Abrasion	Fabric, leather, coated fabric.
Cuts and Blows	Leather reinforced with steel, metal mesh.
Electricity	Rubber.
Moisture	Coated fabric, natural rubber, plastic, glass fibre.
Acids, Alkalis and other chemicals	Natural rubber, neoprene, P.V.C.
X-rays	Rubber, leather, plastic with lead lining.

10.4 Foot and Leg Protection

Adequate foot protection may have to be provided to the workers employed in certain jobs. Risk of injury may be in handling of heavy materials, caustic and corrosive liquids, wet conditions, molten metals, etc. Common foot and leg protective devices are safety shoes and boots, leggings, foot-guards and leg guards. Shoes and boots may be provided with steel toe-box and inner steel able, and they may be ankle, calf or thigh or hip high. They may be made of leather, asbestos, neoprene, natural rubber, synthetic rubber.

Leg protectors may be in the form of leggings whish may be know high and they may be spats which should be lower shin, ankle and instep. They may be held in position by straps or spring clips or snap fasteners.

10.5 Body Protection

Sometimes it becomes necessary to provide special protective equipment for the body in the form of aprons, coveralls, jackets and complete head to the protective suits. Nature of potential hazard, degree of the hazard involved and nature of activities of the person concerned are important considerations in the selection of safety clothing. Although complete coverage of the body and legs is not needed in many cases and unnecessary safety clothing may hamper the efficiency of the worker, no compromise should be made with strict safety requirements. If a worker needs complete coverage, he should have it.

Besides the above five groups of protective equipment there are devices for protection against noise in the form of ear plugs and ear muffs and safety belts for working in pots or at heights or in confined spaces.

5.10 CONCEPT OF RELIABILITY AND CALIBRATION

1. RELIABILITY

Reliability can be termed as the extent to which any foreseen circumstances arising during operation of the chemical plant can be handled safely and effectively with the existing systems and devices.

Safety systems such as alarms, trip systems, relief systems including necessary treatment and flaring systems are extremely essential for reliability.

For achieving the best of reliability conditions the following factors are considered as critical:

i) Good design and selection of safety systems and trip systems which can give a good level of reliability even at the worst possible conditions
ii) Efficient operation, maintenance and regular checking of the individual components of alarm, shut down and other safety systems.
iii) Establishment of safety teams which conduct safety audits, hazard and operability studies, hazard analysis and risk identification to suggest and implement safety systems.
iv) Continuous training to all concerned personnel such as operators, engineers and other associated people who are involved in the operation and maintenance of the plant.

In addition to the above, it is also essential that a common awareness is built among the community and society.

1.1 Standards

It is essential that strict standards are maintained during design, construction and operation of the plant. Standard specifications have to be established for the construction, commissioning and operation of the unit. This standard specification depends upon the nature of the materials that are handled, as well as working temperature, pressure, etc.

1.2 Design

Various international and state standards have to be met during the design of the plants. Some of them are:

i) ASME pressure vessel standards for pressure equipment
ii) API Codes for atmospheric and pressure storages
iii) ANSI Standards for different types of piping
iv) BIS Standards for various equipment
v) State and Central Govt. laws viz Acts & Rules such as the Factories Act and Environmental Regulations, etc.

2. CALIBRATION

Process variables like variable temperature, pressure, flow, level and physical properties such as density, viscosity, thermal conductivity, refractive index, calorific values, index of fuel gases, vapour pressure, boiling points, chemical composition, etc. can be measured by different methods. Instruments or devices used for recording all these variable parameters in a chemical process are required to be maintained in a good working order all the time. For this purpose, calibration of the instruments/devices to read the above variable, plays a vital role for efficient and safe performance of a plant. Hence, all the measuring instruments and sensing devices for process variables are be given adequate care and attention in their calibration with specified periodicity. In other words, calibration of indicating / recording instruments to measure various parameters in a chemical process is an important factor to judge reliability of performance of a chemical plant.