10
Chemical Process Safety

Objectives

When you have completed study of this chapter you should be able to :

- Know the responsibility of the individuals;
- Be aware of the duties of the safety supervisor;
- Apply the standard safe working rules;
- Understand the chemical hazards and safety data sheets;
- Know the various types of safety procedures.

10.1 Safety Responsibilities

10.1.1 Safety Responsibilities of Individuals

The responsibilities of employees towards safety are outlined here.

- Safety Rules are designed basically to protect employees in the plants against any potential hazards. The employees have a responsibility to protect themselves, their fellow employees and plants by way of proper compliance to safety Rules and Regulations
- Employees should periodically go through various safety Rules, Instructions and Procedures and follow them
- Employees are also expected to observe various notices, danger signs, on the job safety instructions etc provided at various plants/departments
- Safety equipment is provided for the safety of the employees and they are expected to wear them as and when required
- It is the responsibility of the employee to promptly report any dangerous or unsafe condition which comes to his notice to his immediate supervisor

10.1.2 Responsibility Of Supervisor

- The supervisor, a person in charge of man and job, regardless of ordinary designation, is considered for the purpose of definition the 'Supervisor'
- The supervisor must ensure that the worker engaged in any job or operation is fully aware of hazards associated with the job and they are following the safe methods of working
- A responsible person must be present when a job involving high hazards is carried out. It must not be left to the workers to decide whether the job is safe or not
- The supervisor must go through all the safety rules and ensure that they are followed in the interest of safety
- It is the responsibility of the supervisor to follow various permit systems during maintenance and repair jobs in plants or work areas
- The supervisor should arrange to maintain all the Safety Equipment, Fire Extinguishers and First Aid Boxes in good condition and in easily accessible

positions. In case of any defect or non-availability, they should try to get it from the department concerned

- It will be the responsibility of the supervisor to ensure that the worker is dressed in suitable clothing and uses the right type of protective equipment wherever required
- The supervisor checks by doing frequent rounds of the plant or work area that all jobs are being done with full safety precautions
- The supervisors should familiarize themselves with statutory requirements on safety and follow them in their work area
- The supervisor must always set the right example by strictly following all safety rules and taking the right type of precaution in any job and by wearing safety equipment provided

10.1.3 Responsibility of Safety Personnel

- The main function of the safety department and safety personnel will be to develop safety consciousness amongst all levels of employees in order to reduce accidents and losses
- The safety personnel will mainly function in an advisory capacity. In order to check observance of safety rules and practices; they will make frequent safety inspections of the plant and various departments
- They will also advise plant or maintenance deptartment whenever any major or jobs of hazardous nature are planned at the plant
- Safety personnel will guide plant and management on the requirements of various statutory regulations and will ensure that proper compliance is attained. In case they observe any violation, they will bring it to the notice of top management
- Safety Department will organize various safety training programs to train the employees on safe methods of working

10.2 Standard Safe Working Rules

10.2.1 Basic Safety Rules and Regulations

The purpose of basic safety rules and regulations is to make all employees aware of the various safety precautions to be observed in their day to day working. The basic safety rules are meant for safety of individual employees and operating plants and work areas. All employees must study the rules and regulations thoroughly and comply with them while working.

- Smoking is not permitted in any part of the operating plant/areas except in smoking booths/locations specifically designated and permitted for smoking
- When working around moving machinery or in plant, the wearing of loose clothing is prohibited.
- Shift employees should not leave their jobs until the relief staff are properly advised of all operating conditions
- As a safety measure, employees must not walk through or across any operating units unless their duties require them to do so
- Do not attempt to operate any machine or equipment to which you are not assigned

- Personal protective equipment must be worn by employee while handling corrosive and harmful chemical substances
- All employees including contractor staff shall wear safety belts to give protection in performing jobs at elevated locations of more than 10 feet high, where adequate protection or working platforms or proper guard rails against falling is not available
- In addition to the requirement to the wearing of a safety belt while working in elevated positions, the employees shall also wear safety belts with a long rope attached to it when they enter any tank/vessel or sewers or closed locations
- Before starting any repair or maintenance work in the plant make sure you have obtained the necessary safety permit
- All protective guards on pumps, compressors, moving machinery etc must be fitted at all times. If guards are removed for maintenance work, then guards must be in place before handing over the equipment for operation
- Compressed air must not be used for cleaning or blowing dust out of clothing or body
- Drums, full or empty, should not be used as work benches or supports for platform or in place of a ladder to avoid any personal injury as well as fire due to welding sparks
- Employees should be careful to clear up after a job is finished. Left over junk or material or tools are to be removed to its proper place once the work is completed
- Good housekeeping should become a matter of habit. Keep your plant, machines and surroundings clean and keep everything in its proper place
- All stairways, platforms and walkways must be kept clear at all times
- Only approved safety torches are to be used in operating plants/areas
- Whenever your clothing becomes saturated or contaminated with chemicals while working in the plant, immediately remove the clothing and wash body parts with water
- Washing of clothing with any of the solvents or chemicals is strictly prohibited
- Vehicles must not enter operating plants without proper authorization and exhaust muffler. Only authorized plant or emergency vehicles are permitted to enter operating plants/areas
- Use of flash cameras or any other non-flameproof instruments or machines in plant is not permitted without properly authorized permits
- The speed of vehicles, while driving inside the complex, should not be more than the permitted limit. Only employees, outside visitors or transport drivers in possession of valid driver's licence will be permitted to drive vehicles inside complex
- Fire Department must be informed immediately when any fire equipment had been used or are found to be removed so that it may be replaced without delay
- Possession or use of alcoholic drinks or narcotics within the plant premises or reporting to work while under the influence of alcoholic drinks or a narcotic, is strictly prohibited
- When any dangerous accident or fire is noted, it should be reported immediately to the Fire Department and to the Area supervisor in charge
- All employees should report to industrial Medical Center for periodical medical examination as and when required

10.3 Chemical Hazards and Chemical Safety Data Sheets

The various chemicals handled and processed can be classified in terms of the following hazards:

- Fire & explosion Hazards
- Toxicity Hazards
- Reactivity Hazards

10.3.1 Fire and Explosion Hazards

There always exists a potential danger of fire and every care should be taken to prevent its occurrence.

Chemistry of Fire : There are three ingredients which must simultaneously exist to cause a fire.

- Spark
- Air
- Fuel

To prevent fire, it is therefore necessary that one or more of the above three ingredients should be so controlled as to be non-existent. In case of a fire, one or the other of the three factors must be removed to extinguish it.

Figure 10.1 - The fire pyramid explains the necessary components of a fire.

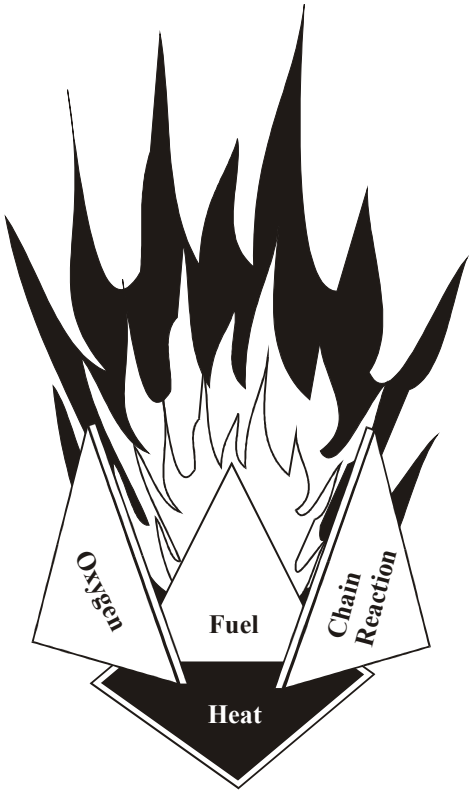

Figure 10.1
Fire Pyramid

Some of the possible causes of fires are:

- ***Smoking and Matches :*** Smoking is a dangerous practice where flammable or combustible substances are handled. This can be prevented by strictly enforcing "no smoking regulations"
- ***Open Flame :*** Use of open flame, gas cutting and welding can cause hazards. Such jobs should only be permitted after making the area safe or with proper hot work permit and adequate precautions
- ***Friction*** : Hot bearing, misaligned or broken machine part, jamming of material can create a spark or temperature. Proper maintenance and inspections could be prevent this.
- ***Electrical :*** These are principal causes of Industrial fires. Electrical equipment should be properly designed and installed in flammable area. Electrical equipment and wiring should be properly maintained to avoid any short circuiting or spark. Non-Flameproof Electrical equipment should not be brought into flammable area
- ***Hot Surface :*** Hot surfaces of Heaters, furnaces, Boilers can be a source of fire in the event of leakage of flammable liquid or gases. It could be prevented by avoiding any leakage from equipment/pipe line at the source of ignition
- ***Foreign Substances :*** Presence of foreign substances in process can cause fire
- ***Spontaneous ignition*** : Oily waste and rubbish or presence of combustible material in the storage of material can cause spontaneous ignition
- ***Overheated Material :*** Abnormal rise in temperature in process or moving machine can cause ignition

- ***Static Electricity :*** Static charge can develop during flow of liquids/vapours (hydrocarbon, acids steam etc) or powder/solid substances

Classification of Flammable Liquids :

As per NFPA -USA code the flammable liquids are divided into two classes.

- Class A Liquids, those having flash point below 100 deg F and may be sub divided as follows:
- Class 1-A Liquids, those having flash point below 73 deg F and having a Boiling point below 100 deg F
- Class 1-B Liquids, those having flash point below 73 deg F and having a Boiling point above 100 deg F
- Class 1-C Liquids, those having flash point at or above 73 deg F and below 100 deg F
- Class B Liquids, those having flash point at or above 100 deg F and below 140 deg F

10.3.2 Health and Toxicity Hazards

Apart from other hazards in industries, occupational health hazards must also be controlled. The occupational health hazards which may adversely affect an employee, are usually classified as follows :

- Toxic chemical agents
- Biological agents.
- Physical agents

Chemical agents in the form of a) Dusts (b) Fumes (c) Mists (d) Vapor (e) Gases.

Health Hazards associated with biological agents are not associated directly with industries in general.

Physical Agents usually include (i) Noise (ii) Extreme Temperature and humidity (iii) Abnormal Air pressure (iv) Vibration (v) Radiation.

Chemical substances reach the body through

- Inhalation
- Skin Contact
- Ingestion

Control Measures and Precautions

- All leakages of gases and liquids from plant, should be controlled and maintenance of the plant and equipment should be improved
- Spillage of chemical substances on floors should not be permitted. In case of any spillage, the area should be thoroughly washed with water
- All drums and containers of chemicals should be kept closed to avoid any evaporation and thus affecting the environment
- Housekeeping of plant should be improved. Rubbish, water material and drums should regularly be removed from the plant

- All employees are advised to observe personal cleanliness. They must wash their hands before eating foods or eatables
- All employees are advised to make use of personal protective equipment like hand gloves, barrier cream etc to avoid any skin contact with chemicals
- Washing the hands with any solvent or chemical is prohibited
- Employees can make use of Gas Mask or Airline breathing mask on jobs where there are chances of exposure to gases or vapors while working
- Employees should periodically be medically checked and examined at Industrial Medical Centre as per schedule

10.3.3 Chemicals Safety Data Sheets

The chemical safety data sheets give useful information on hazardous properties of chemicals and on safety aspects of handing individual chemicals. These data sheets can be used as data guide and reference for day to day operation and use.

The definition and meaning of various terms of properties used in data sheets are given below:

- Flash Point

  The flash point of flammable liquid is the lowest temperature at which it gives off enough vapors to form a flammable mixture with air near the surface of the liquid or within the tank or container

- Fire Point

  The lowest temperature at which a liquid in an open container will give off enough vapors to continue to burn once ignited, is a fire point. It is generally slightly above the flash point

- Explosive Limit

  The explosive range or limit includes all concentrations of mixtures of flammable vapor or gas in air (usually expressed in % by volume) in which a flash will occur or a flame will travel if the mixture is ignited. The lowest percentage at which this occurs, is the lowest explosive limit and the highest percentage is the upper explosive limit. If such a mixture is confined and ignited, an explosion results.

- Auto ignition Temperature

  The auto ignition temperature of a substances whether solid, liquid or gaseous is a lowest temperature required to initiate or cause self-sustained combustion in the absence of a spark or flame. The temperature varies considerably depending upon the nature, size and shape of igniting surface and other factors

- Vapor Pressure

  Vapor pressure of a liquid is the pressure of vapor at any given temperature at which the vaporand liquid phases of the substances are in equilibrium in a closed container. Vapor pressure varies with temperature and are useful in evaluating the relative tendency of any given liquid to evaporate under any unknown set of conditions

- Threshold Limit Values (TLV)

  Threshold Limit Values are set by the American Conference of Government Industrial Hygienist, (AGIH). According to the AGIH, these values represent conditions under which it is believed that nearly all workers may be repeatedly exposed daily without adverse effect

Interpretation of Hazard Code Symbol

H - Health

F - Fire

R - Reactivity

1 - Low

2 - Medium

3 - High

4 – Extreme

For gas and vapors, the TL value is usually expressed in parts per million (ppm), ie part of the gas or vapor per million parts of air.

For fumes and mists and for some dust, the TLV is usually given as milligrams per cubic meter.

- Minimal Lethal Dose and LD 50 Test

In experimental toxicology, it is common practice to determine the quantity of poison per unit of body weight of an experimental animal which will have a fatal effect. The amount per unit of body weight which will cause even one fatality in a group of experimental animals is known as Minimal Lethal Dose (MLD). A more commonly figure in experimental industrial toxicology is the amount which will kill 1/2 of a group of experimental animals. This is known as LD 50 test representing 50% fatalities.

10.4 General Safe Practices

10.4.1 Safe Furnace Firing

Furnaces are essential, similar distillation columns, vessels and various heat exchangers in all hydrocarbon industries. These are designed for specific services and operating conditions vary accordingly.

Operating of furnaces requires special skills and thorough knowledge of the operating procedures. Inadequate knowledge of the equipment and procedures have lead to many incidents resulting in damage to the equipment and personnel loss.

Furnace Defined

Furnace may be defined as an enclosed space in which heat is produced from the chemical oxidation of a fuel. The geometry of the furnace also depends on the type of burners and services which are utilized within a given furnace.

Furnaces look very dangerous when they are in operation and appear to be harmless when not in operation. But as a matter of fact, a furnace is most hazardous when it is not in operation and attempts are made to light it. Safe heater operation is completely dependent upon the controlled release of fuel into a confined space, furnishing a strong source of ignition and maintaining the fuel air ratio within explosive limits.

a) Furnace Lighting and Shutdown

The following should be done before lighting any type of furnace burner.

- Look into the firebox to be sure that there are no flammable materials such as wood, paper or rags. Be very sure there is no accumulated oil in the firebox. Remember that oil or gas can seep into the firebox through the floor of a furnace setting on the ground
- Brick up access openings if required and close all observation doors and access openings. Header boxes and plates should be closed tightly. Air should only enter the furnace through burner registers
- Re-check fuel system valves for proper setting. All defective valves in the fuel gas and fuel-oil lines should have been repaired and tested during the shutdown
- Be sure that fuel valves and cocks at the burners are tightly closed
- Adjust the draft gauges to proper zero setting and open them to the furnace. Be certain that all air and fuel-gas ducts are free from oil and water
- Be sure that all burner air registers and the stack damper are wide open. Furnaces designed to operate with forced or induced draft fans, should never be lighted off or operated under natural draft condition
- Start the fans that provide air to the firebox as soon as possible after the firebox is closed up. Operate the fans at the specified rate for the specified time to obtain a thorough purge of the firebox
- Remove the blind from the furnace fuel-gas line
- Check the fuel gas system. Drain any liquid accumulation accordingly to safe procedure. Do not leave the drain open
- Purge of furnace

  On natural draft furnaces, use a steam purge to heat the air in the firebox and produce a draftas follows:
  - If the furnace has combination burners, shove the oil gun forward into firing position and open the steam valve wide. Don't open the oil valve
  - If the furnace only has gas burners, use steam lances inserted through burner openings
  - Steam long enough according to instructions to obtain an adequate draft and free the firebox of possible flammable mixtures
- When you are ready to light the first burner
  - Ensure that the number of people in the vicinity of the furnace is at an absolute minimum
  - Adjust both the air flow through the burner to be lighted and the total air flow in accordance with unit operating instructions, so that a stable flame can be obtained

- Ensure that the fuel oil pump is running and circulating oil at the required temperature and pressure if fuel oil is to be used

Lighting Gas Burners

The following rules are to be followed for lighting gas burners

- Prepare the furnace as outlined in the above section
- Shut off purge steam. Be sure the firebox is warm enough to create a draft before you shut off steam
- Open the main block valve in the gas line. This will put full line pressure against the control valve blocks and bypass, if any
- Shut off primary air requisters on premix gas burners to prevent flash back when lighting
- Standing to one side, insert the torch through the opening of the burner to be lighted and open the burner gas valve slowly. If the burner does not light in the short period of time specified, shut off the burner gas valve and remove the torch. The firebox must be re-purged before attempting the next light-off
- When the fuel ignites, open the primary air requisters until the yellow flame turns blue. Don't extinguish the flame by opening the requisters too much
- Never light one burner from another

Lighting Fuel Oil Burners

- Adjust atomizing steam/air to the burner to the minimum requirement
- Ensure that pilot burner is on
- Gradually open the fuel oil valve so that fuel immediately catches fire. Wait for a few seconds and finally adjust the atomizing steam/air and fuel oil to a suitable stable flame
- If the burner does not light immediately and oil is sprayed from the top of the burner, shut off the oil and purge with the steam for a few minutes
- Check for an adequate fuel oil temperature, stable flame of hand torch, dryness of atomizing steam and presence of water in the fuel oil etc
- Relight the burner as set out above
- Ensure a staggered pattern of burners to maintain equal heat distribution inside the furnace

Switching Fuels

The steps in switching from oil to gas on combination burners are as follows

- Increase gas to ensure gas burner will stay lighted
- Close the oil block valve on the header
- Open the steam bypass and flush the oil out of burner to prevent coking and plugging. Flush the oil cock, moving the handle back and forth
- Shut off steam entirely, unless a little is required to prevent freezing during winter or to keep the tip cool
- Adjust the gas to meet heat requirements

Normal Shutdown

- Maintain good heat distribution with staggered pattern of burners while individual burners are shut down to reduce heat rate

- Close the oil burner valves and gradually reduce the atomizing steam and close the valve. Ensure that pilot flame is not extinguished and that there are no flashbacks in premix burners
- When the main fuel valve for gas burner seems closed, it is necessary to shut some burners off entirely to continue adequate fuel pressure on the rest of the burner. This prevents all burners from extinguishing as well as flash-backs in premix burners
- Close the fuel gas to pilots
- Ensure that all the valves in fuel lines are closed properly
- Keep air flow on for some time

Normal Operation

When the furnace is in service a regular check on the following is necessary

- Pressure of fuel gas/fuel oil/steam
- Draft of the furnace
- Burner and flame condition/impingement on the tubes
- Refraction lining of the furnace
- Tube condition inside the furnace, hot spots and carbon deposition
- Oil/Gas/Steam leaks around the furnace

Hot Spots and Soot Formation

Hot spots on the tubes inside the furnace are observed due to improper flow of the fluid within the tube caused by to some obstructions like catalyst crumbling, coke deposition etc and consequently has an effect on heat transfer. If hot spots are noticed and corrective actions are not taken in time, tubes are over-heated and due to thermal stresses, it leads to failures and ruptures. Whenever hot spots are detected the flames within the vicinity of the tubes should be controlled and skin temperature of the tube should be maintained low during soot blower operations. Draft is to be adjusted and flames stability should be checked. Any rise in temperature of tubes should be watched and controlled.

Some Points To Remember :

- Use a firing shield when looking through furnace peepholes
- Light each burner the way you lit the first one. Never try to light one burner from another. Light all pilots before lighting any main burner
- If one burner goes out while the others remain lit, shut off fuel to that burner for five minutes and then relight with a torch
- Prepare a check-list for startup or shut down of furnaces so that nothing is forgotten

10.4.2 Safety in Boiler Operation

Most of the accidents that occur in a boiler are mainly due to unsafe operations of the firebox. The following are the major causes of explosions in the boiler, which require special attention during start-up/normal operations/shut down.

Causes of Explosion of Boiler Firebox

- Insufficient purge of firebox and fuel passage causes the boiler start up explosion

  Conditions promoting this cause are
  - Leaking fuel valves to burners and pilots
  - Ignition system failure with repeated attempts to relight pilots and burners
  - Adequate manual purge procedures not followed
- Fuel/air ratio not properly balanced accounted during the start-up

  Conditions promoting this cause are
  - Improper air flow when lighting first burner resulting in accumulation of fuel rich atmosphere followed by increased air flow for lighting other burners
  - Interruption of fuel or air supply resulting in concentration of explosive mixture
  - Flame failure without automatic shut down of one or more burners in the presence of other burners operating normally
  - Unknown fuel leakage into firebox through valves of unlit burners or pilots
  - Sudden shut down of one or more boilers with other boilers trying to pick up the load without proper combustion control limits
  - Partial loss of draft without a corresponding reduction of fuel gas flow
- Failure to follow light off procedures

  Conditions promoting this cause are
  - Lack of communication between operations.
  - Lack of complete knowledge of start up procedure
  - Short cut of the procedure
  - Lack of sufficient training
- Component failure of combustion and safety control systems

  Conditions promoting this cause are
  - Draft system malfunction
  - Instrument air system malfunction
  - Main fuel gas control valve failure
  - Leaky block valves in fuel gas line
  - Liquids in fuel gas line
- On-line explosions during normal operation are operator errors

  Conditions promoting this cause are
  - Lack of thorough and frequent training
  - Lack of proper instrumentation that will give the operator the information he needs to make correct decisions

- Improper draft caused by equipment failure

  Conditions promoting this cause are

  - Steam and hot water backing into the drum through these connections can cause injury and death
  - Ensure that the number of people in the vicinity of the steam generator at start up is at an absolute minimum

10.4.3 Moving Machines, Pumps, Compressors, Turbines etc

- All moving machines, pumps, compressors, blowers etc. shall be provided with suitable protective guards to avoid any danger to the operating personnel
- All guards should be securely fastened to the machine or to the floor
- The protective guards should not be removed from the equipment and whenever removed for any maintenance or repair work of the machine, it should be put back before the machine is put into operation
- The department attending to the work on the machine is responsible for refixing the guard in position
- Whenever a new machine is installed, provision for guards or other protective devices should be made before the machine is put into operation
- No work will be carried out on moving machinery unless it is stopped and electrically isolated
- No repair or maintenance work on moving machinery should be started without obtaining a written "Work permit" from the production or operating department
- Proper caution notices of "Men at work" should be displayed on switches of the machine before starting any work
- The operating staff should ensure, before starting, that nobody is working on the machine
- Leakages of harmful chemicals or gases from the gland packings may cause serious eye injuries to the operating personnel. Damaged or worn out gland packing of pumps should be replaced
- Operating personnel should check that both suction and discharge valves of the pump are in open position while pump is running . Otherwise pump impeller and casing will heat up and in case of pumps used for flammable liquids, this may constitute a serious fire hazard
- Operating staff should not forget to start the cooling before starting the compressor or blower meant for flammable gases, and this should also be checked
- There should not be any abnormal rise in pressure or temperature of compressor/blowers used for flammable gases. In case of any abnormality, the equipment should be stopped to avoid any serious fire or breakdown
- Wherever such equipment is provided with automatic tripping device for abnormal rise in temperature and pressure, it should be ensured that such devices are in perfect working order
- Safety valves or other pressure relieving devices installed on compressors or its connected pipe line, receivers etc should be maintained in good working condition. Such devices should be regularly checked by operating staff and in case of any defects, this should be immediately brought to notice of higher authority

- Leakages of flammable gases from the compressor or from its connected pipe line should be promptly attended to and rectified to avoid any fire hazards
  - Slow rate and steady pumping are preferred
  - Avoid loading/unloading after sunset and during storms, lightning etc
  - Always use explosion proof lamps/torches for inspection etc
  - Avoid unauthorized and unnecessary entries to the area. Only the minimum number of persons should remain during the operation
  - Each person must know the fire fighting appliances provided in the area and they should be trained in fire fighting
  - Parking of waiting tanker should not obstruct the fire fighting operation in case of emergency
  - Entering tanker compartment is strictly prohibited
  - Leak test must be done after filling the tanker/wagon; Keep water hose ready for use in emergency
  - In case of any abnormal situation, immediately inform the supervisor/operator concerned
- Filling drums/Containers
  - The type of drums/containers (of suitable construction material) will be determined by the chemicals
  - Drums/containers should be free of any contaminant and leak proof
  - Containers should be positioned as near to the filling point as possible
  - Proper ground/bonding of the container should be done and checked before filling to take care of static hazards
  - To avoid splash filling either hose should touch the wall of the container or extended to the bottom
  - Filled containers should be properly closed to avoid any spillage/leak
  - Wherever applicable storage license have to be obtained from department of explosives and safety provisions mentioned there in should be strictly adhered to
  - Minimum and steady flow rate to be maintained to take care of static generation
  - No hot work to be carried out without the necessary fire and safety permit on any drums when liquid are emptied out
  - Drums should not be used as scaffolding for persons to stand and work on
  - The contents are to be properly labelled on the drums along with safety precautions
  - Any leaky/defective drum should be separated, contents to be transferred and areas wiped off to avoid fire/accident

10.4.4 Safety in Laboratories

Safety is our day-to-day need in the chemical industry and we cannot just overlook the importance of safety measures while working in laboratories. Though laboratories are considered less hazardous than plants, there are potential hazards involved in handling chemicals and other activities. These can be minimized by knowing how to handle chemicals properly and then putting that knowledge into practice.

a) Good Safety Practices

- Safety - It is everybody's business. Safety is your responsibility. Get into the habit of thinking of Safety as you do of your technical duties
- Don't Let Familiarity Breed Contempt

  Experience shows that most of the accidents or near accidents are the direct result of operations/experiments which have been carried out many times before
- Check all new operations carefully

  Consult the literature and superiors and obtain all possible information on new operations that you plan
- Familiarize yourself with Safety and Fire Equipment
- Practice 'Good Housekeeping'.
- Obey the rules outlined
- 'Don't Be Afraid To Ask If You Don't Know.

b) General Safety Precautions

- All the tests and experiments must be carried out by following the safety methods as directed. Performing any test or experiment outside the scope of approved laboratory facilities and procedures or without permission of Supervisor is forbidden
- Before leaving work, ensure all appliances and equipment not required to be used, are properly turned off, disconnected or otherwise rendered safe; particularly electrical/gas equipment
- Never distract the attention of another employee unnecessarily. Employee should give their fullest attention to their job at all times to prevent accident and mistakes
- Do not allow gas to escape from gas burners. It can cause an explosion hazard. When gas burner is to be lighted, open gas tap and apply lighter spark simultaneously
- Be sure that the chemical reaction will not develop pressure or create any hazard to person, appliances and in the work area
- Bottles should be carried in the carriers
- Tests requiring the use of an open flame, shall be restricted and only allowed in designated location
- Never pick up dry ice with bare hands. Use spatula
- Use hand gloves, apron and eye protection while handling acids and corrosive chemicals to avoid injuries
- When drawing samples of toxic and corrosive products use proper protective equipment

- While drawing samples from operating units, inform the Shift Engineer or Operator in charge of the unit before drawing the sample
- All containers of chemicals and samples should be labelled clearly and correctly. All unlabeled materials should be discarded under the direction of the supervisor
- Liquefied hydrocarbon sample must not be stored in glassware
- Draw samples slowly and cautiously, particularly the samples with high temperature and pressure
- When taking samples, never stand on the side of the opening where escaping vapors or liquid will flow towards you. Keep sampling valves closed at all the times, except when actually sampling
- Cork borer shall be kept sharp and lubricated with glycerol-alcohol mixture when used. Always bore through from both sides to meet in the centre and rotate the stopper occasionally during the boring to aid in the palm while boring
- Before inserting glass tube into stopper hole, moisten the hole and the tube with water or glycerine. Hold the stopper firmly with the thumb and forefinger and gradually push it byrotating the tube
- Air pressurizing system in the laboratory should be kept operative to maintain positive air pressure within. This will prevent entry of flammable gases from outside
- All laboratory personnel must be familiar with location and the use of fire extinguishers, safety showers, eye baths, fire blankets, gas masks and electrical switches. Fire/safety equipment will not be blocked by placement of materials
- When using compressed air for cleaning/drying/glass ware, crack open the valve. Excess pressure can cause hazard

c) Hygiene

The following rules should be adhered to with regard to personal and general hygiene

- Food must not be stored in laboratory fridges or iceboxes and must not be left on laboratory benches. Prior to taking meals hands must be washed thoroughly with soap and water
- It is advisable to protect hands with barrier cream before handling solvents
- Hands should be washed promptly after handling chemicals
- Laboratory glassware must not be used for handling chemicals
- Do not use compressed air to clean clothing or the skin
- When new or unfamiliar chemicals are encountered make every effort to determine their hazards before handling them. In case it cannot be determined, treat them as toxic or otherwise hazardous materials

d) Eye Protection

All laboratory personnel will be provided with safety goggles (spectacle type)

- Working with any glass apparatus maintained under positive pressure or negative pressure such as vacuum distillation etc
- Using acid bath melting point apparatus which may break and splatter hot acid into the employees eyes

- Opening bottles of any acids, alkalies or other corrosive chemicals. Pressure is frequently built-up, especially during warm weather
- Opening glass stoppers of containers containing corrosive material may cling to the glass stoppers and splatter upward on opening, creating hazard to the openers eyes
- While diluting concentrated acids, especially sulfuric, the heat generated often results in splattering. This hazard can be mainly reduced by adding the acid to water, stirring slowly
- Working with perchloric acid or its salt, it should be remembered that certain commercial drying agents are salts of perchloric acid. Perchloric acid or perchlorates will explode on contact with organic matter
- Working with strong alkalies and acids (or solutions)
- Exposed to danger of chemicals splashing
- Chipping dry ice etc

e) Use Of Hood

Hoods should be used for any operation which may give off flammable vapours, poisonous orobnoxious odors

- The efficiency of its exhaust systems should be checked periodically to ensure that adequate air flow is maintained. (Do not allow materials like paper bits being sucked into duck. It may cause choking)
- Over a period of time 'peroxides' can form in the hoods and ducts. To avoid peroxide hazards in hoods and ducts, they should be washed periodically in water (a record of such cleaning should be maintained)

f) Procedure For Taking Samples From Plant

- Only authorized persons of plant should be allowed to take sample from the plants
- The person collecting the sample should be fully aware of the hazard of the plant and also of the properties of sample chemicals to be collected
- Whenever new persons are allowed to take samples, they should be properly instructed by the process staff
- When sampling hot or corrosive liquids, the operator must wear safety equipment like face shield or goggles, hand gloves, aprons etc
- Great care must be taken to ensure that undue strains are not put on the sample point, valves and their connection. Any damage to the sample point can do as much harm as the bursting of a pipe line, resulting in immediate plant stoppage or plant having to be stopped for repairs
- The damage to the sample line can also cause serious injuries to the operating personnel due to sudden splashing of chemicals
- There can also be a serious fire hazard in cases of damage to the sampling line of Flammable liquids or gases
- Sampling valve should be opened slowly and in case nothing is coming out, then close the valve immediately. Try to remove the chocking slowly by putting rod or wire inside the sampling point, keeping the valve close. Do not try to remove the chocking by keeping valve in full open condition
- At the time of removing chocking, try to stand away from the point and at the opposite direction of air. Wear complete protective equipment for such jobs

- If sampling points become completely obstructed then the sample collector from the other department should not try to attempt to clear it but should bring the defect to the notice of the Shift Engineer concerned
- Before samples are actually taken, it is necessary to purge the sampling toxic or harmful gases in a confined area, collect a volume of gas sufficient to purge the line in a sample bottle or rubber bag and release this outside the building. Sampling line must not be purged into confined space
- When collecting samples of highly toxic or poisonous chemicals, make positive use of gas mask or oxy breathing apparatus
- Sampling containers should be placed a few inches below the sample cock so that if any liquid flows out under pressure, it will not splash out of the container
- When collecting samples in glass bottles full line pressure must not be put into the bottle. When taking such samples, a Tee (T connection) with rubber should be used, keeping onebranch of the Tee wide open the other being connected to the bottle. The open end of the rubber tube should be pinched down slowly until the sample bottle is filled at the desired rate
- Sample or containers of different chemicals should be kept separately and properly labeled. The sample bottles of one chemical should not be used for taking samples of other chemical without thoroughly cleaning and washing the bottle

10.5 Good Housekeeping Plan

A good housekeeping plan has a substantial effect on minimizing the accident rates, fire hazards and operating costs, etc

For improvement of housekeeping, guidelines to be considered are:

- General appearance (neatness)
- All walk ways and approaches must be cleared and freed of obstructions
- No leakages are to spread near to the product storage area
- No leakages of utilities (steam, water, air, gas)
- All drains must be clean and properly covered
- All materials and spares are stored in a neat and orderly manner
- All machinery must be free from spillage of oil or grease
- Cotton waste and paper waste are not scattered in the plant area
- Service hoses, tools, equipments, drums etc kept in a orderly manner
- All safety appliances are kept in the proper locations
- All caution/signs and display boards are kept in position and updated
- All furniture and fixtures are in good condition
- Roofs and fittings are free from cobwebs and dust
- Collection of garbage and scrap in proper containers and waste bins cleaned regularly
- No loose and hanging electrical wires. All electrical fittings are in order
- Lavatory blocks and wash basins clean and in good condition

10.6 Personal Protective Equipments

10.6.1 Selection and Use of Personal Protective Equipments

It is based on the factors mentioned below

- Nature of hazards against which a particular equipment is required to be used
- Standards and occupational safety and health requirements on various hazards in the work area
- Selection and procurement of different equipment as per the required quantity and inspections /issue practice in the organization
- Methods of procuring/maintaining the safety equipment
- Effective methods of training and motivation of employees so that they are used as and when required

10.6.2 Types of Personal Protective Equipments

Personal protective equipment is classified into two main categories, ie

- Non-respiratory
- Respiratory