Unit - 3 ❑ Fire Prevention

Structure

3.1 Good House Keeping

3.1.1 Introduction

In general, housekeeping means the care and maintenance of the property. But in terms of fire prevention, Housekeeping means a sence of cleanliness, orderliness, as well as repair and maintenance. All these aspects are important on the following reasons :

- **To prevent fire.**
- **To minimise the spread of fire.**
- **To preserve a clear escape route.**
- **To provide easy access for fire fighting.**

Good housekeeping is a basic requirement for all types of facilities from the simpliest dwelling to the most complex and largest industrial facility or warehouse.

It is important that each facility must have a written housekeeping programme in place. To be effective, this programme should include the involvement of all facility employees. An important part of this programme should be a fire safety plan that includes housekeeping practices which should include provisions for inspection, equipment layout, storage and handling practices and an effective preventive maintenance programme to limit or eliminate potential sources of ignition.

In addition to reduced fire hazards, a well planned housekeeping programme can get the following benefits :

- **Reduced operation costs.**
- **Increased production.**
- **Improved production control.**
- **Conservation of material and parts.**
- **Reduced product time.**
- **Better use of space.**
- **Increased traffic flow.**
- **Reduced accident time.**

3.1.2 Good Housekeeping Practice

Good housekeeping is not a sophisticated concept - it is just a common sense. It relates to keeping everything in its place, keeping facilities and equipment in good repair and in good operating condition and peeping processing areas free from accumulations of byproducts and waste materials.

Statistics revealed that for each serious fire that is reported, there might be 10 major fires, 100 minor fires and 1000 "unsafe condition" near misses that could lead to a fire.

The number of unsafe condition may be high or low but can cause a fire or are the factors that allows the fire to spread uncontrolled. If one can recognise these conditions and eliminate them, the potential for a disastrous fire will be substantially reduced. This can be accomplished through good inspection procedures and good housekeeping.

Poor housekeeping increases fire and explosion hazards in several ways :

- ❖ It provides more place for a fire to start.
- ❖ It creates a greater continuity of combustibles, which makes it easier for fire to spread.
- ❖ It provides a greater combustible loading for the initial fire to feed on.
- ❖ It creates the potential for flash fire or dust explosion when layers of lint or dust are allowed to accumulate.
- ❖ It allows spills or drips of flammable or combustible liquids to accumulate, which could catch fire (including spontaneous combustion in some situations).
- ❖ When not properly addressed, friction, static or electrical connections can be source of ignition.
- ❖ Poorly controlled smoking policies can lead to a source of ignition.
- ❖ It increases the potentials for spontaneous ignition.

In addition to the increased hazard, poor housekeeping can have a negative effect on production in the following way :

- ❖ Quality is hard to maintain when workplace is crowdy and noisy.
- ❖ Efficiency suffers, because people normally tend to work faster and more accurately if the surroundings are clean. This hamper due to bad housekeeping.
- ❖ Poor maintenance of workplace and inadequate aisles not only restricts the free flow of materials into and out of the workplace but also good exit capabilities.

Thus good housekeeping not only prevent fires and possibly save lives, but also it can improve production and employees moral as well.

The degree of effort and attention neded for proper housekeeping is influenced by the type of building, the processes going on, and the oppupanices of the facility.

Some processes produce more waste, leakage and vapour than others, thus contributing to the extents of housekeeping problems, in addition the acceptable level of cleanliness varies from occupancy to occupancy. What is satisfied in a foundry would probably not be acceptable in an office building.

For the purpose of good housekeeping, the programme must start at the top. The top facility management must set the tone and plan the programme. To effect this, all facility employees should be involved in the programme under the direction of individual supervision, or team leader, or crew leader at the department level. But the success of such effort will be much improved if the top management of the facility is behind the programme.

First of all, team leader (at all levels) must be trained to know what is meant by good housekeeping. Each level of leadership is then inspect the facility to have an idea about the present status of housekeeping maintained and to determine the following:

- ❖ Acceptability and adequacy of the present level of housekeeping.
- ❖ Availability of appropriate tools for general plant clean up and their availability for emergency cleanup.
- ❖ Adequacy of storage areas provided for both incoming raw materials and outgoing finished products.
- ❖ Requirement and involvement of leadership to improve housekeeping as per necessity of the facility areas.
- ❖ Provision of adequate and appropriate waste receptacles in different workplace of the facility.

Giving importance on the aforesaid subject, a fire safety plan including good housekeep as keystone to fire prevention, should be formulated for strictly observance in the facility.

Proper housekeeping does not just happen it requires support and direction from management as well as the cooperation and participation of all employees visitors and vendors. Good housekeeping requires effort from every one. The management should ensure the following :

- ❖ Set the tone, specially, the level of acceptable housekeeping.
- ❖ Enlist the aid of everyone to help.

- ❖ Solicit the employee ideas on how to maintain good housekeeping.
- ❖ Act on the ideas of employee to maintain good housekeeping and if not, explain the reason.
- ❖ Acceptance / confirmation of the responsibilities for housekeeping in their respective areas by all employees of the facility.
- ❖ Ensure that, materials, tools, wastes, and so on, are placed in their respective locations is the job of each employee who handles them.

When proper housekeeping does not exist, it is usually because inadequate attention is paid to or inadequate action is taken in, one or more of the areas of equipment, layout and storage, communications, environment, personnel etc.

3.2 Requirements for Good Housekeeping

There are three basic requirements for good housekeeping which are as follows:

A) Proper Layout and Equipment

Over crowding and improper layout is a major impediment to proper housekeeping. Blocked or restricted aisles limit the access and lack of sufficient workspace and storage capacity results inefficient operations, an inability to maintain order, and worker frustration. The creative use of racks, shelves, and bins, or making aisles and storage areas by painting lines on the floor can provide solutions.

Housekeeping efforts should not hamper from lack of necessary tools or equipment. The simple step of placing a sufficient number of easily accessible waste buskets or trash receptacles at points of need can reduce the amount of waste deposited on the floor or in the product.

A well planned preventive maintenance programme on all equipment will find and eliminate leaks of liquid, electrical hazards, static build up and friction caused by lack of lubrication.

B) Correct Material Handling and Storage

With the negative influence on good housekeeping, disorganised and haphazard storage is usually a detriment to effective fire protection as well. Fire extinguishers, hose reels, sprinkler system control valve etc can become blocked and inaccessible, while other fire and life safety equipment like fire doors, may not be aperable at the time of fire emergency.

As a result of which, in a fire emergency, it will be more difficult for the fire department to attack and extinguish a fire even in a sprinklered building. Proper material handling allows for materials to be moved to their specified location without stagging them in an area that does not contain the needed level of fire protection.

C) Cleanliness and Orderliness

The type of operation will dictate the level and frequency of cleaning required. Many locations will only require per day, but some manufacturing processes might require at the end of each shift, or even periodically during the shift.

In pursuing cleanliness and orderliness, effective care and maintenance of buildings require special housekeeping practices to reduce the fire danger to buildings with special attention to :

i) Floor cleaning :

When floor is concern, the general care, treatment, cleaning and refinishing of floor may present a fire hazard if flammable solvents or finishes are used or if combustible residues are produced in quantity. Some times flammable liquids are used to clean greasy spot on the floor from which fire may be resulted. In general cleaning solvents with flash point below room temperature are too dangerous to use to clean floors. When selecting a cleaning agent, care should be taken about its toxicity to human being and to the environment if it is discharged through the sewer system. Safe nonhazardous cleaning agents should always be preferred.

ii) Dust and Lint Cleaning :

The housekeeping procedure in many occupancies is the removal of combustible dust and lint accumulations from walls, ceiling and exposed structural members. The cleaning procedure should be performed safely as by vacuum cleaner or air moving (blower and exhaust) system, otherwise it may present a fire or explosion hazard. In some cases vacum cleaning equipment must be equipped with dust ignition proof motors to ensure safe operation in dust full atmosphere.

Care should be taken not to dislodge into the atmosphere any appreciable quantities of combustible dust or lint which might ignite or form an explosive mixture with air. Blowing down dust with compressed air may create dangerous dust clouds and such cleaning should be done only when other methods can not be used and after all possible ignition sources have been eliminated.

All duct systems can accumulate dirt and whatever other materials is dispersed in the facility. Frequent cleaning of these systems is necessary for good housekeeping. Filters must be changed frequently. Particular attention should be given to building ventilation systems, including fire cut-off devices.

The exhause ducts from the hoods over cooking range, such as those found in facility cafeterias present troublesome problems due to condensation of grease insides the ducts and on exhaust equipment which can be ignited by spark from the cooking range or by small fires in overheated cooking oil or fat.

There is no practical method for preventing all kitchen duct fires, but the danger can be minimized through the good practices i.g., to clean hoods, grease removal devices, fans, ducts and all associated equipment frequently. The exhaust system should be inspected daily or weakly, depending on its use.

In cleaning the exhaust system, avoid using flammable solvents or other flammable cleaning aids. Do not start the cleaning process until all electrical switches, detection devices, and extinguishing system supply cylinders have been turned off or locked in a "shut" position which should be returned to normal operating position once the cleaning process is completed.

The use of professional cleaning company or specially trained employees should be considered to ensure proper handling of the dust and dirt from the ducts. This is specially true if the dust is combustible or explosive, since special equipment is needed to clean this type of system.

3.3 Housekeeping Programme in Buildings

Special consideration must be given in housekeeping programme to disposal of rubbish, control of ignition sources and other housekeeping hazards. It is a good practice to cause an inspection by a responsible officer after employees has left the facility for the day or weekend. Special attention need for :

a) Rubbish Disposal

The intension of disposal of rubbish in regular basis is not to give fire a place to start. The proper handling and disposal of rubbish is an integral part of housekeeping programme and its success depends primarily upon preparing and observing a satisfactory routine. The proper and regular disposal of combustible waste products is of the utmost importance.

When combustible waste products are concern, it is needed the removal of such waste products at the end of each work day or at the end of each work shift in both industrial and commercial properties. In high fire hazard properties, more frequent waste disposal is necessary. In others, the collection, storage and disposal routine vary with the nature of the property use. To keep a place tidy and fire safe, enough waste buskets, bins, cans and other proper container should be provided, so that building users will find tideness convenient.

Non-combustible containers should be used for the disposal of waste and rubbish. Which is true even for small receptacles as ashtrays and waste buskets. Care should be taken to avoid mixing waste materials'where such mixing introduces hazards of its own.

It is not good housekeeping practice to dump all waste in a common or storage receptacle. Precautions should be taken to keep combustible items separate from each other and from non-combustible items.

b) Control of Ignition Sources

i) ***Control of Smoking :*** Inspite of repeated warning and prohibitory notice, there are still a significant number of people who do smoke in work place. The best policy is prohibit smoking all together which eliminates the possibility of smoking materials being improperly discarded. Where this is not a possible consideration, smoking regulations must be specific as to location, and preferably time. Areas in which smoking is permissible, as well as those in which it is limited or prohibited entirely, must be clearly marked by appropriate signs that leave no doubt as to what is allowed where.

In addition to sensible regulations, smoking control also requires adequate receptacles made of non combustible materials for spent materials in industrial buildings, large con tain ters of sand are often used to conveniently and safely extinguish and dispose of spent smoking materials.

Improperly designed ashtrays may constitute a hazard, particularly of they allow a lit cigarette to fall or roll away. There are thousand instances where fire is originated from a lighted butt come in contact with combustible materials.

ii) ***Control of Static Charges :*** Static charges can be produced by the flow of dissimilar materials past each other. As for example, liquid or dust conveyed through a pipe or duct produces an electric potential. If adequate oxygen is present, a static discharge can occur that can ignite the flammable vapour or combustible dust. This can be avoided by providing adequate grounding and bonding of the apperatus or equipment.

As such, annual inspection and testing of all grounding including building grounding and bonding should be included in the annual maintenance programme.

iii) ***Control of friction :*** A preventive maintenance programme must be formulated and observed to identify and eliminate potential sources of friction. Lubrication, properly designed ball and bearing etc are important part of the programme.

iv) ***Control of Electrical hazards :*** Nearly 80% fires are originated from different defects and malfunctioning of electrical systems and equipment. Routine inspection can identify and rectify overloaded electrical circuits, excess electrical extension cords, missing grounding plugs, improper protective devices etc.

3.4 Housekeeping Programme in Industries

Due to nature of their operations, some industrial occupancies have some specific housekeeping problems as stated below for which specific planning and arrangements are necessary.

a) ***Lubricants and Coatings:*** Paints, greases, thinner and similar other combustibles are widely used in industrial occupancies, for which a good housekeeping programme must be established to collect and disposed them safety and regularly. Arrangement should be made to discharge the vapour from the spray boths directly to the outside and the residues accumulate safely.

b) ***Disposal of Corrosive and Flammable Liquids Wastes :*** The corrosive and flammable liquid waste often presents a serious problem while disposal. Any waste material that is a corrosive liquid (ph < 2 or > 12.5), or is a liquid having flesh point of 140°F (60°C) or less, is considered as hazardous waste. These waste products must be disposed of through an agency who is licensed to handle this waste.

c) ***Drip Pans :*** Drip pans are essential at many locations, e.g., under motor, machines; using cutting oils, and bearings, including boring and turning that may contain oil. Drip pans should also be used wherever flammable and combustible liquids are dispensed. Drip pans should be made of non-combustible material and contain an oil absorbing compound in the form of diatomaceous earth but not sand or sawdust. It is recommended to remove the oil soaked material regularly.

d) ***Spillage of flammable liquid :*** Where flammable liquids are handled or used, it is anticipated that some form of spillage will be there and to cope up with these spell, some means and measures must be kept in hand. These include a supply of suitable absorptive material and special tools to help limit the spill. Arrangement must be there to cut of sources of ignition, proper ventilation of the area and safety dissipate any flammable vapour if so needed in emergency.

e) ***Storage of flammable liquids:*** No storage of flammable liquids should be allowed in the general storage area which should be stored in a segregated area with adequate fire protection, prevention and ventilation. Good housekeeping practices will ensure that only limited quantities of flammable and combustible liquids are kept on the production or work area which should the protected in suitable container.

f) ***Oily waste :*** Oily wiping rags, lint, clothing, sawdust and other oil soaked materials can be highly dangerous, particularly if they contain oils subject to spontaneous heating. A standard waste can for small quantities and heavy metal barrels with cover may be used for disposal of all such materials. Good practice calls for cans and barrels containing daily waste to be emptied daily.

g) ***Packing materials :*** Almost all packing materials used today are combustible, as such hazardous. Large quantities of packing materials should be kept in store room duly protected with automatic sprinkler system.

   Used and waste packing materials must be removed and disposed of as quickly as possible in order to minimise the danger of fire. A specially marked area should be identified to accumulate this materials. This area should be cleaned frequently and the debris removed to an outside storage receptacle.

3.5 Outdoor Housekeeping Practices

Like indoors, good housekeeping practices of outdoors are equally essential. Failure to comply with good housekeeping practices, outdoor can threaten the security of exposed structures and goods stored outside. The most common outside hazards are accumulation of rubbish & waste and the growth of tall grass and weeds adjacent to the facility building or stored goods. Adequate precautions should have to be taken to protect the goods and building from outside hazard, some of them are listed below.

a) **Grass and Weed Control**

Dry weeds, tall grasses and bushes around the facility building, on railroad properties and along the streets of large industrial and commercial complexes present a definite fire hazard. Fire can spread from one building to another or from the vegetations to be building. To reduce this hazard, vegetations around buildings and outside storage should be control and destroyed through the use of common herbicides.

b) **Outdoor Storage**

Proper separation of outdoor goods stores from any structure of combustible materials or from other combustible storage should be ensured that might constitute an exposure hazard. These separation must not be blocked by contractors employees shed, discarded crates, pallets or other combustible. One of the important duty of the housekeeping staff to see that these separations are never blocked, even temporarily. Obstructed passage way or aisle and dedicated space separation not only help the fire to spread from one area of storage to another, but also hamper fire fighting operations.

Proper housekeeping also requires that smoking in outdoor storage areas be

c) Outdoor Rubbish Disposal

Outdoor storage of combustible materials awaiting for disposal as rubbish should be stored not less than 3 m and preferably 15 m from building and atleast 15 m from public roadways and sources of ignition like incinerators. They should be enclosed with a secure non-combustible fence of adequate height.

Regular collection and removal of rubbish from the premises is the most satisfactory solution in achieving good housekeeping. Burning of rubbish is general unsafe, but if its is permitted it should be done in a non combustible container.

3.6 Inspection of Housekeeping Programme

Housekeeping inspections as a part of the combined safety inspection programme are an important part of overall housekeeping programme. This type of inspection has many objectives, such as :

- ❖ Maintain a safe working environment.
- ❖ Control unsafe acts and actions of the machineries and employees.

- ❖ Maintain operational environment, result product quality and profit ability.
- ❖ Maintain fire and life safety systems and equipment in perfectly working contain.
- ❖ Restrict the spread of fire.
- ❖ General comfort and satisfaction of the employees and management.

There are several types of inspections. Some involve preventive maintenance of the equipment and systems and some involve inspection and testing of fire protection systems and equipment.

One of the most important part of an inspection is writing a report. In addition to normal registers, computers and barcoding can help to maintain inspection report. At the compeletion of the inspection, the informations is downloaded into a computer and a report is printed. This format also allows comments to be made where employees have made positive contribution to the housekeeping programme. This positive reinforcement will encourage employees to continue their good work.

To prevent inspection from taking considerable time, the inspection authority should

- ❖ Have a definite schedule.
- ❖ Inspect only one part of the department at a time.
- ❖ Rotate inspection responsibilities, among department members.
- ❖ Make housekeeping programme as a compulsory part of daily routine.

A sample fire preventive housekeeping check list highlighting the important points to be observed during inspection is shown in the table 3.1 :

Table 3.1

Fire Preventive Housekeeping Checklist

Sl. No.	Item	Points to be checked during inspection
1.	Housekeeping	Accumulation of rubbish. Safe storage of flammables. Clearness of the passages / asiles. Storage of unneccessary combustible materials. Spillage, leakage or drippling of flammable in the flower. Obstruction of sprinkler head. Materials blocking exit signs, mannual call point extinguishers etc.

Sl. No.	Item	Points to be checked during inspection
		Free operation of fire door, blockage etc. Regular rubbish disposal. Floor cleanliness. Use of cans, bin, receptacles. Orderliness and cleanliness.
2.	Fire Extinguishing equipment	Proper type and number. In proper location. In proper working order. Last date of servicing. Easy access to the system & equipment. Training of the personnel in use of equipment.
3.	Electrical equipment	Proper wiring and layout. Serviceability of extention cords. Proper maintenance of motors, switch gears and other tools. Protection of the circuits with fuses, M.C.P. etc. Approved equipment for use in hazardous areas. Proper earthing and bonding. Lightening arrester. Fire protection in major electrical installations and equipments.
4.	Friction	Proper lubrication of the machineries. Proper adjustment and alignment of machinary. Safeguard agaisnt static charges.
5.	Welding and cutting	Survey of the area for fire safety. Removal or covering of combustible for the area. Issue and observance of “Hot Work Permit”. Inspection of the area on conpletion of the job.

Sl. No.	Item	Points to be checked during inspection
6.	Smoking and matches	Marking of "No Smoking" everywhere. Strickiest vigilance. Restriction of carrying matches inside the facility.
7.	Spontaneous Ignition	Preservation of flammable waste materials in closed metal container. Proper cooling, drying and ventilation of piled materials. Frequent cleaning of flammable waste material contaners. Daily clearence of trach receptacles.
8.	Static Electricity	Proper grounding and bonding of flammable liquid dispensing vessels. Maintenance of proper humidity. Proper grounding of moving mechinaries.
9.	Hot Surface	Clearance of combustible materials from hot pipes etc. Clearance around boilers and furnaces. Keeping of the combustible surfaces from soldering irons. Ashes in metal container.
10.	Open Flame	Keep away from spray rooms and flammable storage. Maintenance of clearance between portable torches and flammable surface. No gas lick.

Atlast it can be summerised that housekeeping practices are an integral part of any programme to prevent or limit the source of ignition and spread of fire. Building care and maintenance, occupancy and process housekeeping (including disposal of rubbish and control of ignition sources), appropriate outdoor housekeeping practices and inspections are the key element to acheive the goal of success.

3.7 Electricity & Its Fire Hazards

3.7.1 General Introduction

Electgricity is something real which can not be seen but its effects are felt. It may be defined as a form of energy, energy can neither be destroyed not it can be generated. It can only be converted from one form of energy of the other. Electricity is generated by converting other forms of energy i.e., Thermal (Feat) energy, nuclear energy and energy stored in water (potential) energy. Similarly electricity can also be converted into other useful forms of energy viz., heat energy, methanical energy, light energy, etc. which finds a wider application in our day to day life.

3.7.2 Fundamentals of Electricity

Electricity may be defined as they flow of electrons. The continuous flow of electrons through the conductor is known as current and the path of its flow is termed as electrical circuit. The dynamic electricity (current) is of wo type vin.,

(i) the direct current (D.C.)

(ii) the alternating current (A.C.)

The direct current always flows from positive terminal to negative e.g. Battery torch where as in case of 'temating current (A.C.' there is a rapid change in direction of flow which occurs many times per second.

The flow of electricity through a conductor can be compared with the flow of water through pipes and, thus, has same flow of characteristics parameter like quantity, pressure resistance, etc. Which are defined below:—

(i) Electromotive Force (E.M.E) 'V' : This refers to the pressure or tendency to cause flow of electrons in a circuit, its unit is volt.

Current 'I' the flow of electrons is called current and its unit is Ampere.

(ii) Resistance 'R' : It is the property of the materials by which it opposes the flow of electrons (electricity) through them. Its unit is ohm.

Ohm's Law:—This law states that in any electrical circuit, current is directly proportional to the pressure (Volts) and inversely proportional to the resistance in the circuit provided the temperature does not change.

Mathematically,.

$I \alpha V$

and $I \alpha \frac{I}{R}$

Combining the two, we may write

Or $I = V/ R$

Or $V = RI$

Or

The above equation is known as ohm's Law, equation where 'V' is pressure in Volts, 'r' the current is Ampere and 'R' the resistance in ohm.

Heating Effect of Electric current:

When current passes through a conductor heat is produced. This is in fact the work, that is required to be done in sending the current against the resistance, which is converted into heat.

Heat produced in the conductor is directly proportional to

(i) square of the current passing through conductor I^2

(ii) The resistance of the conductor 'R' and

(iii) the time of flow 't' .

Combining the proportionalities, we may write $\frac{V}{I} = R$

H = 0.242 FRT

Where 'H' is heat produced in Calorie, 'I' is current is Ampere 'R' the resistance on ohm and 't' is the time of flow in seconds.

This phenomenon is particularly important to fire-fighters as"the heat so produced if not dissipated safely, wil! raise the temperature which' ultimately' ignites the combustible materials available in the near vicinity.

Conductors & Insulators :

Conductors are the materials which allows the flow'of electrons through them with least resistance e.g. Copper, Allbrriiniunv ifoti, watef, etc. whereas the insulators are the materials which do not allow the flow of electrons through them e.g/ Wood (dry), rubber, plastic, glass, mica, etc.

3.8 Generation and Distribution of Electicity

The bulk production of electricity is done by converting other foriris of energy viz. heat and potential energy at places which are known as power stations. In Inida, the most common power plants, indude

(i) Thermal power stations,

(ii) Hydropower station,

(iii) Nuclear power station,

In a thermal power station coal is burned to produce heat energy Which is utilized in converting water into steam (temperature about 535 C and pressure 150kgf/cm2) which in-tumruns the steam turbine thereby converting the pressure energy is further utilized in rotating the generators to produce electrical energy.

In hydro power station, water is collected at higher attitudes, which when allowed to flow at lower level discharges water at high pressure. This high pressure flow rotates the water turbine converting the pressure energy into mechanical energy which is subsequently utilized for running the generators to produce electrical energy.

In a Nuclear power station fission reactions in radio-active materials axe allowed to take place in Nuclear reactions which produce heat energy. This heat energy is used in converting water into steam for running the turbines which gives mechanical energy. The mechanical energy so produced is used in running the generators to produce electrical energy.

The electricity produced at either of the three power station is a low pressure (voltage) current and since, for distributing the electricity at distant places, high pressure (voltage) is as required and electrical equipments, namely transformer are used to increase the pressure and then through transmission lines electricity is transmitted to distant places. Since, low pressure (voltage) current is the requirement of the consumer hence wherever tapping done step down transformers are used to reduce the voltage depending upon the consumers requirement and then supplied to the users. Step up transformers are used at power generating stations where as step dowpitransformeis are used of electrical substations.

3.9 Common Causes of Electrical Fires and Remedial Measures

Fire hazards of electrical origin are mainly due to the improper use of electricity, improper electrical installation and lack of care in the maintenance of the electrical systems and apparatus. Fires are mostly originate mostly from the sparks of overheating of electrical equipments which may be caused by the following :

(1) Short circuit

(2) Failure of insulation

(3) Overheating of electrical equipment

(4) Improper selection of equipment/wiring

(5) Loose electrical contacts

(6) Discharge of static charges.

With few exceptions most of the fires originated by electricity can be prevented by

(i) Selecting the proper rating electrical equipment and wiring.

(ii) Avoiding the excess loading of electrical equipment.

(iii) Using proper capacity fuse /circuit breaker.

(iv) Ensuring effective earthing of electrical equipment and installation.

(v) Periodic inspection and testing of electrical circuit and equipments.

3.10 Static Electricity and its Hazards

As its name indicates it is the electricity at rest. Thus, flow of electrons does not take place instead positive and negative charges are developed. These charges go on accumulating if not dissipated.

Static charges are produced due to contact and separation of two non-conducting substances. The rate of production of static charges depends on how quick by contact and separation is taking place. The accumulated static charges causes high-voltage, built-up and these charged get dissipated, giving off sparks, if a connector is brought near to it. These sparks are capable of igniting the flammable gas/vapour air mixture which may lead to explosions.

Remember static charges pan not be prevented from generation but its hazards can be prevented by not allowing the accumulation of these charges. The production of static urges are most common in the following industries—

(1) Textile Industry :— Static charges are produced due to contact and separation of fabric to various machinery.

(2) Rubber Plastic and Similar Industries :— In such industries static charges are produced due to milling, mixing, spreading and extruding excesses.

The static charges are also produces on machinery belt drives, conveyor systems, paint and spraying, grinding, dry cleaning etc.

Safety against hazards of static electricity :

Remember the generation of static charges in any process is not hazardous but the accumulation of these charges on the equipment generating static charges is a cause of concern. The basic principle if safety against the hazards of static electricity is to prevent the accumulation of these charges and this can be achieved by—

(i) ensuring proper earthing if all equipment (connecting the equipment to the earth by a good conductor)

(ii) Artificial humidification (pressure of moisture in atmosphere)

(iii) Neutralizing the static charges using radioactive materials and/or by applying electrical field (high 'voltage) to Ionize the air in the near vicinity;

3.11 Electrocution

If a fireman comes in contact with a live conductor, he may receive Electric shocks, which may be even fatal. It effects the Hearts, the nerve centre in the brain governs the functioning of the respiratory muscles. For this Artificial respiration should always be done. The resistance of human body is 1500 ohm but when a firemen is wet or standing on water, it acts as in good conductor. A.C. with 30 V or more may produce a severe shock, currents in excess of 2 milliamps are most dangerous for D.C.

If a person is in contact of live electric wire, his body forms a part of the circuit and any effect to touch him is same in touching the live conductor, where high voltages arc involved, the best solution lies in isolating the current At lower voltages rubber gloves, dry hose may be used to pull the clear of the circuit. Woolen Jersey, Coat, Silken cloth may also be used for medium volts.

To switch off the curent whenever possible is to be made and artificial respiration must be resorted immediately to the victim.

3.12 Fire Fighting

In any fire involving current, the first essential is to render the circuit dead. Where it is not possible, non-conducting extinguishing media viz. COr vapourising liquid, DCP, Dry sand, asbestos, etc. are to be used normally. Foam and water streams may be used with great cam, keeping in consideration the danger of live wire. The safe distances for using water jet are :

VOLTAGE	1/2" Nozzle	1" Nozzle	Spray, fog
132KV	29'—0	64ft	9ft
33KV	18ft.	44ft	6ft
11KV	4ft	32ft	6ft
40 volts.	5ft	10ft	6ft

Safe distance should never be less than 5ft Breaking or indirects jets are very effective and safe. Cutting off the current to a high voltage installation such as cables, Transformers switch gear, does not necessarily render it safe. A resistance charge (actually static electricity) may be present and mad' Electrocution. For this reason, they must always be Earthed before it is touched.

If a fire occurs in underground cable, this street Box of other openings should not be filled with sand, as it may cause situation for explosion.

Fireman is frequently exposed to danger from Electricity in the dark or smoke and should be competent to recognise the hazards in advance, as Electricity is such a familiar and Extensive used energy that we often forget the risks involved in its use.

3.13 Electric Generating Plant

Introduction :

Todays society increasingly relies on the socio economic benefits of electrical energy for residential, commercial and industrial applications. Over the years, in our everyday lives our dependance on electrically powered labour saving devices has greatly escalated. Now electricity is a part of our daily life.

The availability and reliability of the electric supply impacts our lives in many ways which include safety, security and the creation of employment opportunities. Certainly, today's information hungry, service-oriented and computer-oriented society could not function without an adequate and releable supply of electricity.

The process of producting and delivering electrical energy to customers includes three distinctive elements e.g., generation, transmission and distribution. This chapter addresses fire protection for generation of electricity only from a variety of fuels.

There are many means and processes for generation of electricity. These are :

1. Coal Fired Power Plant — Converts fuel to produce steam that spins a generator to produce electricity.
2. Nuclear Power Plant — Use radioactive element's fusion energy to produce steam for spinning the generator to produce electricity.
3. Hydro Electric Power Plant — Uses kinetic energy to spin a generator for the same purposes.

   One other means are also available like wind power unit, solar power unit, Bio-gas power unit etc.

3.14 Coal Fired Power Plant

1) General Plant Design

The "power block" typically houses the steam generator (boiler-furnace), turbine generator and auxilary equipment. Besides this there are coal stacks, coal bankers, conveyor belts, fuel oil tanks, transformer and many other things neccessary for the generation and distribution of electricity in the plants.

Electric generating plants are usually large open structures, perhaps several stories high. Building construction is typically of heatfy structural steel frame with or without insulated metal panel walls depending upon the climate of the area where the plant is located.

In case of fire, the cost of damage can quickly run up into millions. Even fire damage in the secondary area (like coal conveyor belt system) can cause prolonged downtimes for the entire power generation process. In coal fired power plants, in particular, reliable operation is an absolute must, because, they are a crucial pillar of the basic energy supply.

In order to protect people, objects and the environment, a sophisticated and made to measure fire protection system is neccessary.

Power plants are charecterised by their complex overall systems made up of a range of difficult operating modules. In addition to this, conditions such as extremely hot surfaces and lubricating oils pose huge fire risks.

The following are the unique hazards of the coal fired electric generating plant which needs special fire protection systems and preventive activities to save life and properties from fire and explosion.

A) Coal Stockpiles and Coal Bunkers.
B) Coal Conveyor Belt System.
C) Fuel Oil Application System
D) Boilers / Furnaces.
E) Steam Turbine Generators.
F) Cable Channels.
G) e-Room / Server Room
H) Transformers

A) Coal Stockpiles and Coal Bunkers

Coal's principal hazards are combustibility, spontaneous ignition, and potentiality to create fugitive dust.

Coal is transported by a variety of means (by road or rail) and stored in open coal yards without protection against dampness and moisture. Coal bunkers, on the other hand, provide the means to store the coal in dry environment. Coal fired power plant are in general equipped with both storage options.

The damped coal stored in the open yard is susceptible to auto ignition quickly. This enormously increases the fire hazard in the open coal yard. As such, cold stored in open piles should be compacted to prevent spontaneous heating.

Fire Protection : As fire fighting measures, hydrant system and water monitors is generally recommended for coal yard and coal bunkers which can combat fire from a safe distance and cool objects at risk of ignition. The monitors can be aligned with the target manually, electrically or hydraulically by remote control.

For monitoring purposes, thermal cameras showing the development of heat in the in the coal stockpiles are also used. In coal bunkers, generally, gas (carbon dioxide) emission detectors are used to detect a fire.

B) Coal Conveyor Belt System

A coal handling system moves the coal from the storage piles to the boiler furnace via coal crushing units through conveyor belts where it is consumed to produce steam for running the turbine etc. The typical coal conveyor belt is combustible and can ignite from friction between the conveyor belt and the roller, belt stippage, or static electricity. Uncontrolled hot work can also cause fires in coal handling areas. Dump coal can also ignite and therefore presents significant ignition potensity.

Fire Protection : Housekeeping and dust control are vitally important, specially with the coals that are susceptable to spontaneous combustion. A pulverized coal system has significant explosion potential.

The installation of linear heat detectors, gas emission detectors or multicriteria detectors in non-visible area or areas difficult to access is a neccessary protective measure in order to ensure prompt fire detection and activation of the fire suppression systems. An automatic sprinkler system and / or deluge water spray system is needed to protect areas above and below the conveyor belt. Considering the extremely rapid spreading of coal conveyor fires, immediate and wide-spread activation dr extinguishing is required across the entire protected area. Fire retardant conveyor belts are recommended, but they burn under certain circumstances and therefore cannot substitute for automatic sprinkler or water spray projection.

(C) Fuel Oil Application System

In coal fired power plants, fuel oil is used for start-up operations to heat the boiler, before the combustion process is switched to the actual fuel. Some times, very little oil is being added to generation mix for economic reason. Some small capacity plants depend on oil-fired capacity only.

Fuel oil is often heated before it is pumped to the boiler burner tip. Heating equipment may be installed inside the power block. Pipe failure or human error can results in fires involving pumping and heating equipment that expose vital equipment.

Fire Protection : Installation of automatic fire suppression systems to protect the hazard and a minimum of 2 hours fire barrier to isolate it is generally recommended.

Lightning strikes, sparks due to electro static charges and the ignition of the gases in the fuel oil tanks are also causes of fire in the fuel oil storage and systems. The fuel tanks should be protected with foam pourer system and deluge system to cool the side walls and if appropriate the roof of the tank.

(D) Boilers / Furnaces

As a rule, the boiler house is located directly to the machine house with the steam-turbing. The specific conditions in boiler houses mean that the area is particularly dirty, e.g., due to coal dust. Pollution in the form of coal dust deposits can quickly ignite when sparks are generated. In the event of fire, extremely rapid spreading is often the consequences.

Burner front fires are also a significant fire hazard associated with boiler furnace. Two types of burners are located in the burner levels ; Firstly, the coal burner for standard operation where the coal pulverised to dust is burnt and converted the thermal energy in the process; Secondly, the oil burner, which is used mainly for the start up operation, until the coal burner has reached the right temperature for burning coal.

The fire hazard is concentrated on the level of the oil burners. Oil emerging from leaking hoses or flange connections can easily ignite on the hot surface in the area of the burners or at the distribution stations of the oil supply.

Fire Protection : In these areas, fires can spread extremely rapidly with high thermal load. Hence, targeted fire fighting action at the source of the fire, preferably with water mist systems is specially important at the burner levels.

Steam Turbine - Generators

In the steam turbine - generators area, extensive vibration, overspeed, human error, instrumentation failure, blade failure, and filtration failure are the main causes of fire. The fires in the steam turbine - generator area are most serious in nature which may involves live lost, huge property damage and forced outage of many many days.

The main fire challenge of steam turbine generators is the pressurised lubrication oil I system in the range of 10kg/cm^{2}to 17kg/cm^2, that uses a class III B combustible f liquid with a flash point ranging from 204°C to 260°C, and an auto ignition temperature of 371°C. Lubrication oil is released if the lubrication oil piping system is breached. Ignition may occur due to hot surface, which may cause a spray fire, thee dimensional fire, pool fire or a combination of all three, producing large quantities of smoke and heat.

Fire Protection : Automatic sprinkler and heat detectors should be provided over all bearing. All lubricating oil piping, including instrumentation lines above the turbine operating floor and its lagging or skirt area, should be protected by automatic sprinklers. Protecting areas where oil can spread beneath the turbine generator with automatic sprinklers is vitally important. Smoke and heat venting is important in preventing structural roof failure.

Fire suppression is also recommended for the oil storage reservoirs and filtration equipment. Ideally, this equipment should be installed in a room with a minimum fire barrier rating of 2 hours.

The vast majority of generators are hydrogen cooled. Hydrogen explosions inside the generator are considered unlikely as hydrogen is typically 100% pure and therefore there is insufficient oxygen to support combustion. Inspite of that, hydrogen can contribute to turbine-generator fires and cause explosion damage, expected to be minor in comparison to the more severe fire damage associated with turbine lubrication oil.

F) Electric Cable Channels

Whether for power supply or data transmission, countless cables are required for the operation and supply of a power plant. Electric generating plants generally use insulated, jacketed cable for power, instrumentation and control. In order to provide adequate protection, in addition to the aesthetic reasons, cables are typically routed in open cable channels/trays throughout the power blocks.

The main reason for fires in such spaces is overheating with subsequent short circuits, which usually occur as a result of excess load. At the sametime, the enormously high risk of the fire spreading at a very high speed, favoured by the draft air and the numerous cables, must be taken into consideration. Fire which spreads through winding and often in accessible cable ducts can quickly cause interruptions to operation in the whole power plant.

Fire Protection : It is recommended to install cable that posses the standard fire propagation tests. The insulation and for jacketing of many newer cables are of materials that are difficult to ignite. However, under certain circumstances even those cable burns.

A fire risk evaluation should be performed to determine the need for automatic fire sprinkles systems in areas with significant amounts of grouped electrical cables. In area where cables are installed, fire detection systems with optical smoke detectors are used. Ideally smoke aspirating types are favoured, because this system help to detect fires even earlier.

G) e-Room and Server Room

e-rooms such as control room and systems are extremely sensitive and highly valuable facilities. They serve to control the elementory process in a power plant. This makes them simply indispensable.

In these locations, fires mainly occur as a result of short circuits caused by overheated cables or electric / electronic components.

Fire Protection : Concerning fire protection solutions for these areas and the type of extinguishing agents used is crucial. In order to prevent damage to the facilities through the extinguishing media, a completely residue free extinguishing is fundamental. For these areas, total flooding inert gas extinguishing systems using argon or nitrogen is essential. A fire detection system using aspirating type smoke detectors ensures reliable fire detection at the earliest possible stages.

Similarly the server room equipped with computers and servers, monitor etc and control all essential processes of a generating plant.

Faulty or overloaded electronic components can easily cause a smouldering fire or open flame fire. Reliable and residue-free extinguishing action through total flooding system ensure the best level of protection for sensitive equipment in the event of a fire. For server rooms, a reliable fire detection system to detect fire at the earliest stage by means of point or aspirating type smoke detector is recommended.

H) Transformers

Transformers make sure that electricity is ready for network distribution. They function as links between the turbine, the turbine generators and the network. They consist typically of the transformer housing with a cooler, expansion deposits and oil filled insulators.

Electric generating plants use both indoor and outc^oor transformers, usually indoor transformers are relatively small, air insulated and used for individual plant service. Large oil cooled transformers used for main generator voltage step up and for station service are located outdoors. These transformers are usually grouped in an area close to the generator to minimise the length of the isolated-phase bus duct from the generator leads to the main power transformer.

The amount of cooling oil can range from 75000 to 94000 liters. Internal high energy faults can be violent, expending tremendous power, rupturing the transformer casing, releasing oil and subsequently igniting. There have been cases of a transformer fire propagating to the generator, or from the generator to the transformer, resulting two fires simultaneously.

Fire Protection : Transformers with an oil capacity of 1900 to 19000 liters should be separated from adjacent transformers and from buildings by a minimum distance of 7.5 meters or by a fire wall. For best practice, installation should include lightning protection, a drainage system, fire barriers, and automatic water spray extinguishing systems for controlling fire, limiting damage and minimizing plant downtime.

In modern generators, the system is provided that as soon as overheating is detected, the transformer will automatically de-activated in order to prevent a fire from breaking out.

3.15 Life Safety

Life safety consideration is a critical component of the overall design of a electric generating plant. In general, nationally adopted codes govern life safety design for both existing and new construction.

Coal fired electric generating plants are unique structures due to the equipment arrangement required for their operation, and maintenance. These equipment requirements often present challenges in designing for life safety and egress. Large enclosed boiler buildings can be upto 70-75M high and typically consist of multiple grating levels providing access to equipment for maintenance, inspection, testing and repairs. This arrangement requires a continuous vertical opening up to the boiler and in the event of fire, presents a potential smoke hazard to any personnel performing these operation.

In emergency situations, performance of emergency shutdown procedure often delays escape of control room personnel. Therefore, control facilities should have a means of escape separate from other plant areas. At many existing plants, the control room location is such that there is a serious risk of exposure to smoke heat and fire, because it is too close to likely areas of fire origin, such as the turbine generator. Adequate fire barriers and escape facilities are required.

General Fire, explosion and Other Hazards in Coal Fired Power Plant

A) Fire Hazards

The following are the hazard in the thermal power plant having potential to cause a fire.

a) Coal Handling Plant : Coal dust accumulation on conveyor decks, cable trays, head and tail pulleys, crasher house and vibrating screen floors, bunker house etc.

b) Conveyor Belt System: Belt sway, belt tension, failure of belt joints, snapping of belt, partially damaged belt in operation etc.

c) Smouldering coal in bunkers.

d) Jamming of idlers and pulleys.

e) Cables in cable galleries and on trays in plant section.

f) Coal dust deposited on cable trays in mill area.

g) Fuel oil handling and oil tanks (HSD, HFO, Patrol etc).

h) Storage and use of transformer oil, turbine oil, control flude etc.

i) Electrical system.

j) Heat path damaged insulation.

k) Dry grasses.

l) Accumulation of waste materials etc.

B) Explosion Hazard Area

The following are the explosion hazard areas of the plant

a) Hydrogen plant.

b) Turbo generators where hydrogen is used for cooling of generators.

c) Transformer (oil cooled).

d) Boiler (coal / oil fired).

e) Coal dust in mills and boilers.

C) Brusting Hazard of Pipelines, Vessels etc.

The following are the areas of brusting of pipelines, vessels etc which may cause potential danger to the plant.

a) Water / steam pipe due to high pressure / temperature.

b) Hydrogen gas cylinder and gas lines.

c) Acid / alkali tanks.

d) Compressed air header.

e) Compressed air receivers.

f) Hydrogen gas holders.

D) Release of Liquids, Gases and Dusts

The following are the areas where release to liquid, gas dust can be expected which may cause danger situation in the plant.

a) ***Acid and alkali tanks in water treatment plant.***

b) ***Chlorine in water treatment plant.***

c) ***Fuel oil tanks in fuel oil handling sections.***

d) ***Turbine oil and seal oil leakage.***

e) ***Hydrogen in turbo generator area of main plant.***

f) ***Pulverized coal dust from mills and associated piping.***

g) ***Fly ash from chimneys and ash ponds, hoppers and ash system.***

h) ***Coal dust in transfer point, coal handling plant, crushers etc.***

i) ***Fuel gas from the ducts.***

3.16 Inspection, Testing and Maintenance

Fires in the electric power generating plants can have costly and even fatal consequences. Yet, the operators of many plants have paid little attention to proper fuctioning of the fire suppression systems installed in the plant. As a result of which in many cases fire suppression systems fail to operate as expected in the event of fire and caused major destruction of the plant even loss of lives. This type of incident can be prevented with a good documented inspection, testing and maintenance programme, which will result in achieving reliability of the fire suppression equipment.

It has already discussed that fire hazards such as large quantities of fuel, combustible/ flammable liquids and gases, electrical hazards, combustible dusts and warehousing are common in the thermal power plants. A wide range of fire protection and detection systems is found in these facilities. These include fire pumps, hydrant networks, fire extinguishers and systems using sprinklers water spray, dry chemical, ! alon alternatives, carbon-dioxide etc and fire detection and alarm devices.

In addition, some people in charge of the fire protection from the plant side do not have an adequate knowledge of neccessary inspection and testing frequencies, or they use the minimum frequencies prescribed by their authority having jurisdiction. Fire protection and detection systems are a combination of mechanical and electrical components and, like power generation equipment need regular attention. There are few steps to be followed to carryout proper inspection and maintenance and determining the frequencies of testing for the fire protection systems in the electric generating stations. The steps are as follows :

A) The first step in establishing an inspection, testing and maintenance programme is to generate a list of all the fire protection and detection systems at the plant. These typically range from portable extinguishers to sophisticated fire detection and alarm system and automatic suppression systems.

B) Once this list is complete, plant management needs to decide which tasks will be completed by inhouse personnel and which will be contracted out.

   This will depend on the number and complexity of the systems as well as the availability and qualification of the inhouse personnel.

C) The next step is to determine the fequencies of the tasks. The sources for determining frequencies include the local fire department, manufactures instructions, property insurance carrier etc.

D) Then a documentation system needs to be implemented. This can consists of paper forms, a computerized preventive maintenance programme or a modern barcode scanner system. Whichever method of documentation is chosen, the records should be reviewed by management for discrepancies, acceptability of the results and any problem noted. Tliis record should be filed in chronological order in an accessible location for review and use by other parties such as fire department, insurance companies etc.

   Many fires can be prevented and damage can be minimise by improving the reliability of fire suppression equipment. An effective, documented inspection, testing and maintenance programme can help make sure that the system will not fail when it is mostly needed.

Management Policy and Fire Safety Programme

A key element in a well protected plant for management is to establish a policy and follow through on a programme to protect lives, conserve property and ensuring continuity of operation. For an operating electric generating plant this includes.

a) A written plant fire prevention programme, i.e., control of combustibles, good housekeeping, hot works controls etc.

b) A fire emergency plan i.e., action to be taken for control a fire in different sectors, fire and evacuation drill procedures etc.

c) Inspection, testing and maintenance programme of all fire and life safety systems, equipment etc.

In all electric generating plants, an action plan should have to be formulated to ensure that all fire hazards are identified and appropriate strategies are establish to cope with those hazards.

The establishment of a plant fire brigade should be made after considering few variables. Some plants are located in areas remote from immediately available professional fire departments. For these plants, the establishment of a fire brigade may be neccessary. The trend in the power generating industries today is to reduce the size of the plant operating staff which obviously affects the pool of qualified personnel who can perform fire brigade duties. Some smaller plants even operate unmanned or with very few people on a shift. As such rigid automatic fire suppression system and stringent fire prevention activities on those situation are absolutely neccessary.

Fire fighters (plant fire brigade or local fire department) who are expected to respond to the electric generating plant fires should be trained in unique hazards that they could face.

Unit - 4 ❑ Industrial Hazards

Structure

4.1 Fire Protection of Hazardous Industries

Introduction :

The use of nuclear materials has continued to increased worldwide mainly for the production of electric power besides limited use for the purpose of medical, research, industrial, weapons operations etc.

The use and storage of nuclear materials present special fire protection concerns. Although the general fire hazard in facilities that use or store nuclear materials are the same as those of similar facilities that do not include nuclear materials, fires in nuclear facilities may have more significant consequences. Neccessary protection of the employees and emergency response personnel against direct exposure to nuclear radiation is essential. Importance must be given to establish that general public and environment should not be unneccessarily exposed to radiation hazards.

The subject matter will be discussed in the following heading :

- ❖ Nuclear Reactor.
- ❖ Nuclear Safety.
- ❖ Fire Protection and Prevention.

4.2 Nuclear Reactor

A nuclear reactor is a device or assembly for initiating and maintaining a controlled nuclear chain reaction in a fussionable fuel (uranium or plutonium).

Nuclear reactors are used to produce energy, to study the fusion process, or to produce radioactive materials within the reactor. Basically nuclear reactors may be divided into two categories :

- ❖ Large nuclear power reactors, upto 3500MW or more.
- ❖ Research reactors that operate at power levels from a few watts to many mega watts.

  Nuclear reactors that include a contaminent vessel, generating equipment, and heat removal equipment can be as large as largest coal fueled electric generating plants.

  Objectives for achieving and maintaining adequate nuclear reactor safety include the following :

- ❖ Provide means to safely shutdown the reactor and maintain it in safe shutdown condition during and after accident conditions.
- ❖ Provide means to remove residual heat from the reactor core after reactor shutdown, including during and after accident conditions.
- ❖ Provide means to reduce the potential for radioactive releases within acceptable limit.

To meet these safety objectives, different reactors designs provide redundant safety systems so that initiating events, such as fire, do not prevent safety systems from performing their required functions. The modern and advanced reactor designs include a high degree of safety system redundancy. Earlier designs of reactors include less redundancy, as such for those reactors the need to protect each system from the effect of fire and explosions increases. Improved passive fire protection, increased physical separation, and greater use of fire detection and suppression systems often provide this protection.

A higher degree of fire protection is neccessary to ensure that fire will not significantly degrade the level of nuclear safety. The "defense-in-depth" concept can achieve this safety. It includes three principle objectives :

- ***Preventing fires from occurring :*** It requires that plant design and operation be such that probability of fire is minimized.
- ***Detection and quickly extinguishing those fires that do start, thus limiting fire damage :*** This objective concerns early detection and extinguishing of fires by combination of automatic and/or manual fire fighting techniques and relies on active fire protection measures.
- ***Preventing spread of those fires, that have not been extinguished, thus minimizing their effect on essential plant functions :*** This objective places particular emphasis on passive fire barriers and physical separation. This is the last line of defence if the first two objectives are not met.

4.2.1 Power Reactor

Nuclear power reactors have many of the common and special fire protection hazards that are frequently encountered at large industrial facilities. Unique to nuclear power plants are fire consequences that could result in loss of ability to adequately cool the nuclear reactor or that could result in release of radioactive materials. Special attention must be paid in controlling fire hazards in nuclear power plants so that the nuclear safety risks are successfully managed.

4.2.2 Nuclear Safety

Safety performance goals, objectives and criteria can be used to implement an effective fire protection programme for nuclear power plants. Performance based or deterministic approaches for nuclear safety can be used to meet performance criteria. The performance elements are summarized in the table below :

Table 7A.1

Performance **Based Approach to Maintain Nuclear Safety, Prevent Radioactive Release and Provide Life Safety**

Subject	Goal	Objectives	Criteria
Nuclear Safety	Maintain fuel in safe and stable	❖ Achieve and maintain sub critical conditions ❖ Achieve and maintain decay heat removal and inventory control functions. ❖ Prevent fule clad damage.	❖ Prompt negative reactivity insertion to subcritical condition. ❖ Maintain coolant level to prevent fuel clad damage. ❖ Maintain sufficient heat removal to keep fule safe and stable. ❖ Maintain vital auxiliary support for nuclear safety criteria functions.
Radioactive Release	Reasonably prevent radiological release that adversely affects the public, plant personnel or the environment	❖ Maintain containment integrity or ❖ Limit source term.	❖ Radiological release as low as reasonably achievable and less than regulatory limits
Life Safety	Reasonably prevent loss of plant occupants due to fire.	❖ Protect occupants not intimate with fire from loss of life and improve survivability of those intimate with fire.	❖ Provide safe egress or area of refuge for occupants other than essential personnel.

Subject	Goal	Objectives	Criteria
		AND ❖ Provide adequate protection for essential and emergency personnel	❖ Provide adequate protection and lighting for essential personnel to perform neccessary functions.
Plant Damage	Assure acceptable risk of economic consequences	❖ Limit property damage to levels acceptable to the operator of the plant ❖ Limit plant downtown to levels acceptable to the operator.	❖ Limit the probable maximum loss (PML) due to fire to levels acceptable to the operator of the plant. ❖ Limit the plant downtime due to PML fire to levels acceptable to the operator of the plant.

The performance based approach to nuclear power plant fire protection allows for innovative solutions that may be more risk-specific and risk effective than solutions developed through other approaches.

Beyond the effects that fire might have on nuclear safety functions, the fire hazards in nuclear electric generating stations include large volumes of combustible lubricating oils, concentrations of combustible cables, oil insulated transformers, and similar hazards that are common to all other electric generating plant which has already discussed in the portion of coal- fired electric generating plant.

4.3 Fire Protection and Prevention

Fires in any facility that store or use nuclear materials are particularly dangerous because of the hazards associated with nuclear radiation and contamination. In all types of nuclear reactors, a high degree of fire protection is neccessary to ensure that fire will not significantly degrade the level of nuclear safety. The primary goal of fire protection are,

- ❖ Preventing fires from occurring.
- ❖ Detecting and quickly extinguishing those fires that do start.
- ❖ Preventing the spread of those fire that have not been extinguished.

These goal can be achieved by plant construction design, a combination of automatic and / or manual fire fighting techniques, and passive fire barriers and physical separation.

a) Planning for Handling and Controlling Fires

The problems associated with plants using nuclear reactor, radiation machines and other facilities handling radioactive materials are not those types of problems that can be solved by simply calling the public fire department. In any facility handling radio active materials, emergency planning and coordination with the local fire department are essential. The planning should consider the following :

a) The areas where special attention is neccessary must be identified and the procedures to the followed for those special should be thoroughly understood by all plant / facility personnel.

b) Provisions for prompt notification of any fire incident through a reliable fire detection and alarm system.

c) Measures to prevent the spread of contamination and to promptly decontaminate the area in case of accidental release of radioactive substances.

d) The plant fire protection department must preplan fire fighting operation with the local fire department so that they will the properly coordinated with the plant's own emergency plants.

e) Fire fighters and other emergency personnel operating in areas where radiation exposure is a danger must be fully trained and be provided with suitable protective clothing including respiratory protective equipment.

f) Competent radiological advisors, equipped with instruments for measuring area and local exposure, are neccessary to guide emergency personnel.

g) A nuclear reactor site must have a generous water supply to facilitate fire control and decontamination operations. Facilities also must be pre-arranged for safe disposal or storage of water that may be contaminated.

h) The use of non-combustible materials for reactor buildings and equipment will help to avoid complications of fire hazards. For example, all finish materials used for decorative, acoustical, or insulation purpose, should be both non-combustible and easy to decontaminate.

i) All equipment used for handling and processing radioactive materials should be designed to minimise fire and explosion potentials, as well as to protect the personnel against harmful radiation exposure and prevent damage to property by contamination.

j) The hazard of a reactor structure exposing other building to radiation should be prevented by appropriate distance separation or fire barriers.

k) Wiring ducts in floors introduce an opportunity for fire or contaminated liquid or gas to spread from one space to another. Good duct seals separate one space from another.

l) The operations for the preparation of fuel element for reactor should be carried on in work areas separated from the reactor so that fire cannot reach the reactor space.

4.4 Fire Fighting Equipment

Automatic sprinkler systems or specially designed piped water spray system (watermist, high velocity water spray etc) are the first choice for fire protection in any location where fire may occur in nuclear reactor plant, properties housing radiation machines, and facilities handling radioactive materials. Sprinkler can operate with full effectiveness under radiation or contamination conditions that would make approach by fire fighter impossible.

In spaces where water used in fire fighting is subject to possible contamination, as such, the collection and disposal of this water must be provided in the facilities, which means the facilities should have water proofed floors and controlled floor drainage of substantial capacity.

In some facilities where liquid metal is sued as a reactor coolant / moderator, water should not be used which requires special extinguishing systems like inerting with any inert gas like argon, nitrogen etc.

Provisions of hand hold water jet system, hose-reel system, fire extinguishers etc also have to be provided in the facilities for fighting small fires or if the fire turned uncontrolled due to explosion or collapse etc.

4.5 Hydroelectric Plants

Hydroelectric plants do not posses many fire hazards common to coal fired generating plants with respect to combustible fuels and large pressurised lubrication oil system that operate under high pressure. On the other hand, hydroelectric plant present unique fire protection challanges, the most common are life safety (particularly when facilities are several hundred feet below ground level), use of oil filled cable and grouped electric cable, minimum staffing or un-attended operations, transformer exposure, use of hydraulic control and lubrication oil system for pen stock or wicket gates and use of generator windings.

4.5.1 Fire Protection

In general, carbon dioxide fire protection systems have been commonly used to protect hydroelectric generators. However, there are widespread efforts in the international hydro tactic industry to replace these systems.

In some instances, the trend is to replace carbon dioxide system with deluge water spray or water mist systems. This addresses a grass-roots life safety concern with the use of carbon dioxide in below grade area as it is heavier than air gas, and addresses a nationwide effort to reduce green house gas emission. In the water spray system, generally a water ring header is installed above and below the rotor, with nozzles and orifices directing water towards the stator windings. Flow rates depend on iK diameter. Sophisticated interlocks and protective relays ensure that all fields in the generator are de-inergized prior to water flow. Windage inside the rotating generator helps convert the spray to fine mist to penetrate deep seated insulation fires.

In some instances, the trend is to replace carbon dioxide with FM 200 or ine gen. This addresses a life safety concern with the use of carbon dioxide which c >u: migrate to potentially occupied spaces.

However, the implementation of extinguishing system and agent depends upon tht suitability, acceptability, funding etc of the plant and operator.

p) The floor of the manufacturing area should be water proofed. When flammable luqids are stored or used, it should be curved and drained to a point of safe discharge to safeguard property and to prevent against damage by overflow of flammable liquids or by water in the event of fire.

q) The various areas should be separated by fire walls to provide the following :

   i) Raw and semifinished material storage area. ..

   ii) Moulding, extrusion, or processing area.

   iii) Finished material storage, and

   iv) Maintenance and utilities area.

r) In order to properly ventilate a room where manufacturing processes are carried out involving flammable vapours or combustible dusts, air intakes and outlets should be provided in the compartmentation wall on the location befitting for the particular chemicals.

s) Exhaust fans should be provided to remove flammable vapours and combustible dusts from inside the building to the outside in a manner to prevent drift back into the building through air intake equipment of the building.

4.5.2 Electrical Installations

The following electrical safety measures should be incorporated in the electrical distribution system in the chemcial plants.

a) All electrical installations should be in accordance with IS : 1646-1982 and there shall be separate sources of supply to main and ancillary connections.

b) All electrical motors and lighting fittings, and switches should be flameproof and dust proof in hazardous areas as defined in IS : 5572 (Part-I)-1978.

c) Provision should be made for remote control of all electrical circuits, so that the current for lighting and power in the building and facilities can be switched off by switches outside the building at a distance of 1.25m from the nearest doorway. Provision may also be made for switching off the whole factory by switecbes located at one or more central points, such as the office or wachman's cabin.

d) Electrical switches should not be mounted on any machine which produces vibration, while in operation.

e) All incoming feeders from main substation should be through underground cabas.

f) Emergency power supplies system should be provided for adequate supply of power to all emergency lighting, cooling tower, fire pumps, means of escape and other equipment required for safe shut down of the plant.

4.5.3 Control of Spills

As chemical plants process larger quantities of materials, it becomes impractical to provide ever-increasing separation of units. Where toxic, flammable, reactive or otherwise hazardous materials may be spilled, the logical approach is to :

- ❖ Minimise the possibility of uncontrolled spills.
- ❖ Minimise the size of the possible spills. If spills do occur, the design features should keep them small.
- ❖ Minimise the spread of possible spills. If spills are large in volume, design features should keep them confined.
- ❖ Prepare alarm and evacuation plans, if toxic release can occur.
- ❖ Control sources of ignition.
- ❖ Provide protection for exposed propetly, if ignition does occurs.

Large flammable liquid spills should be confined where they may occur. Although diking is often used, it may not prevent liquid around the spill source from burning. Equipment may be damaged further or the spill aggravated unless effecient, prompt and preferably automobile fire control measures are taken.

A number of means are available to control spills, few such techniques are state below :

a) To provide diking or curbing to restrict the spread of spill.

b) To provide drainage to an impounding basin located where a fire, if not extinguished, can burn out harmlessly or a non burning toxic material can be appropriately neutralized.

c) Total confinement of a large flammable gas or vapour spill is not possible, due to gaseous nature of the spill. The use of water spray, using either a fixed sprinkler or water spray system with monitor nozzles (in some cases remotely controlled) to wash out the vapour from the atmosphere is the answer. This method is most appropriate for vapours that are water soluble and also for liquids that can be expected to be released as a mist.

d) Steam frogging systems have also been used to help dissipate vapour release in plants where a large steam supply is always immediately available for this purpose,

e) Foam may be applied to cover the liquid spill so as to restrict the vaporisation of the liquid, carefully considering the physical and chemical properties of the liquid to make sure that the foam is compatible.

Flazardous spills can be kept small by keeping the amount of hazardous materials used in the process small. Where this is impractical, valves to isolate all large quantities of material should be provided. These valves should be installed at each outlet of any large container through which material might escape accidently.

The Distinction between a small spill and a large one must be fixed individually for each plant. A small spill is one that can easily handled by the exposure protection and confinement means. All others are large spills.

4.5.4 Storage and Handling of Materials and Processing Safety.

In the chemical industries, proper storage practice and correct handling of hazardous materials demand prime importance to achieve adequate fire safety in the plant.

There are hundreds of such safety requirements in the chemical plants, few important of which are highlight below in accordance with IS : 11457 (Part-I)-11985.

a) Solid materials should be stored in outside areas provided no hazardous chemical reactions occur due to moisture or direct sun.

b) Bulk storage of combustible, whether raw materials or finished products should be kept separate from manufacturing areas.

c) Only minimum materials required for batch or shift operation should be stored in work areas.

d) Vessel used for storage of products having a flash point below 65°C should be vented to the outside of the building.

e) If should be ensured that no flammable liquids or vapours can be present in the buildings or sections used for storage of combustible materials.

f) Flammable liquid drum storage should be located atleast 20m from all buildings and other storage unless separated therefrom by solid masonary walls.

g) Access drives and areas in the vicinity of the drum storage should be smoothly paved to prevent absorption of flammable liquids. Drums should be stocked at intervals of 5m of separations to permit effective approach.

h) All combustible open storage areas should be'fenced and openings should be provided for fire fighting purposes.

i) Outdoor storage areas should be graded to drain spills away from building and other exposures. Catch basics should be flame trapped to prevent flame travel or ignition in exposure areas.

j) Flammable liquid tanks should be surrounded by bundwalls or dykes of sufficient height to contain the entire contents in case of rapture. Adequate drainage facility should be provided to carry liquid to some areas where it can burn without endangering adjacent buildings or other storage/structure.

k) Tanks should be substantially supported either by resting on the ground or on massonry supports. Full or particial underground tanks are preferable.

l) All openings to the tanks except required vents should be kept securely closed. The vents open to atmosphere should be fitted with flame arrestors or pressure vacuum vents. Each tank should be clearly marked regarding its capacity, flammability and nature of contents. All tanks should be suitably earthed to dissipate static charge.

m) safety containers with anti-flash device and self closing spouts (safety cans) should be used. Open containers should not be used.

n) Durms of solvents should not be stored in working areas.

o) Exhaust fans should be provided to prevent excessive accumulation of dust. When visible in air, it is to be considered as excessive.

p) Storage of volatile chemicals such as benzene, toluene, ethyle accetate etc are highly hazardous to cause fire and explosion which should be stored in, buildings with ventilation both floor and roof level.

Processing Safety

a) Effective cooling arrangement should be provided for removal of heat in the process or operations where heat is likely to be generated to prevent combustion of materials.

b) Provision should be made to control temperature with trip set for a predetermined temperature with alarm.

c) To reduce dust in atmosphere, a dust removal or exhaust system should be provided with hoods located at each operating point where dust is released.

d) All equipment such as hoppers, storage bins, collectors, conveyors, ducts, grinders and blenders should be dust tight.

e) All material separation chambers and dust collectors should be located outside the building.

f) No open flame, naked light, smoking, electric or gas cutting and welding should be permitted within the building containing equipment fdr different chemical process or in flammable tankage areas.

g) All hot work that is welding, cutting, grinding etc which can provide a source of ignition should be conducted only after observing safety controlled conditions with written approval from appropriate authority.

h) All equipment should be earthed to ensure effective dissipation of static charges.

4.5.5 Fire Protection, Detection and Suppression Systems

The fire safety assessment for individual chemical plant shall determine the type of active and passive fire protection system required for that plant. Fire water systems comprising fire water reservoir, fire hydrants, water spray systems, deluge systems, sprinkler systems, fire water monitors are common features that installed in larger facilities. Such systems are activated once the information is received from the scene of the fire that protection is required.

For quick extinguishment of small fires, dry chemical extinguishers are used. Other agents such as foam, steam and carbon-dioxide are also used to provide extinguishment capability.

Similarly careful use of fire resistant materials, such as fire proofing, fire rated cables and heat resistant wiring, can help to prevent a fire from spreading and limit its

damage.

Typically fire proofing is provided for critical structures, vessel and column skrits and supports, exposed pipe-rack columns and control wirings and power cables neccessary for safe plant shut down.

While designing fire protection and suppression system in the chemical industries, the following systems and arrangement should be considered to achieve a reasonable fire safe condition in the plants. These are :

A) Fire Water Supply.

B) Fire Water Pumps and Fire Water Mains.

C) First Aid Fire Fighting Extinguishers.

D) Fire and Gas Detection Systems.

E) Some Other Fire Protection Requirements.

Fire Water Supply

Based on the high risk, adequate supply of the water is-the back bone of fire fighting operations in chemical industries.

The purpose of a fire water distribution system is to guarantee the supply of sufficient water for the prime purpose of fire control and possibly extinguishment at the desired pressure and discharge in the required area. The reliable water supply should, therefore, have following charecteristics.

- ❖ Instantaneous availability at all the points in the plant area.
- ❖ Enough quantity with sufficient pressure.
- ❖ Reliability and continuity.

The capacity of the water storage facilities shall be sufficient for the expected duration of the fire. The storage capacity can be determined with account being taken of periodic maintenance requirements of the fire storage facilities and the available reliable replenishment rates during fire water consumption at maximum flow rate.

In cases where the fire scenarios are not clear or where a longer duration fire can not be excluded, a minimum of 3 hours to 4 hours (depending upon size and chemical proccessed) uninterrupted water supply at maximum required rate shall be provided. It is strongly recommended that water storage facility for fire water and process water should be kept separate. If combined, however, arrangement shall be made so that quantity of water reserved for fire fighting purpose can not be drawn upon for any other purposes. The segregation should be achieved by physical means and not by instrumentation like level switch etc.

Fire Water Pumps and Fire Water Mains

a) Fire Water Pumps

The capacity of fire water pump/pumps should be worked out on the basis of requirement of water supply for fire fighting for atleast one major fire in the plant. The capacity of the pump should be such that it will continue to supply water for fire fighting at the rated capacity without any interruption at a minimum pressure of $7kg/cm^2$. Provision of jockey pump(s) shall be made to keep the water main under pressurised condition at desired pressure.

Fire water shall be prvided by atleast two identical pumps, each of which is able to supply the largest required flow rate to the fire water ring mains system. Another better alternative with higher reliability is the installation of three identical pumps, each able to supply 50% of the largest required flow rate.

The fire water pumps shall be installed in a location which is considered to be safe in the event of fire anywhere in the plant, where it is unlikely to be engulfed in an explosive vapour cloud originating in the plant.

Pumps drivers should preferably be electrical driven with same number of stand by diesel driven pumps. Alternative emergency power supply can be supplied to part of the pumps.

b) Fire Water Mains

Fire water ring mains of the required capacity shall be laid to surround all processing uni ts, storage facilities of flammable materials, loading and unloading facilities, process filling facilities, tanker berthing area, utility, process laboratory etc. The ring main shall be provide with block valves so that sections can be isolated for maintenance. The main shall be laid underground with carbon steel pipes with suitable protection against corrosion and duly protected below roads against damages by moving automobiles. Few important requirements of the ring main fire water system is state below :

i) Fire water main should preferably be minimum of 150 mm in diameter.

ii) No pressure regulating valve should be permitted except where it is absolutely neccessary.

iii) Fire water system should be independent and not connected to process water systems or any other water supply system.

iv) Standard fire hydrant with two outlets for hose connection of 63 mm size should be installed with not greater than 30m spacing between the fire hydrants. The distance requirement between hydrants can be relaxed to 45m for auxiliary building, laboratory etc and relatively less hazardous plants.

v) Suitable type of water spray system shall also be provided to the storage tanks so that the exposed to radiate heat due to fire in nearby vicinity, can be easily protected from the threat of fire.

vi) Supplementary fixed water monitor protection for cooling of vessels is highly recommended.

vii) Highly exposed critical pipe racks, valve manifolds, control equipment shall also be protected with water spray system.

viii) Monitors and fire hydrants should not be closer than 7.5m from plant equipment, buildings or structures.

First Aid Fire Fighting Extinguisher

Portable fire extinguishers shall be provided to enable operating personnel to quickly attack small fires. They shall be located at process, areas, storage areas, loading racks, pump area, compressor houses, electrical equipment and similar facilities etc. Scale of extinguisher at those areas are stated below :

Table 7E.1

Scale of Fire Extinguisher in Chemical Plants

Sl. No.	Description of Extinguisher	Location/area to be protected
(a)	Dry chemical powder fire extinguishers of 10kg capacity.	At process units, pump houses, chemical storage area, tank truck/tank wagon loading and unloading area, electrical equipment, transformer, substation, work shop, laboratory etc.
(b)	Dry chemical powder fire extinguishers of 25/50/75 kg on wheels.	At critical operating areas, chemical storage house etc.
(c)	CO^2 extinguishers of 4.5 kg or 6.8/9.0 kg on wheels.	At sub-station and power station, all other electrical and electronic equipment room etc.

- ❖ The number should be determined based on the maximum travelling distance of 15m in the area as mentioned in the (a).
- ❖ Atleast one fire extinguisher of 10kg DCP type should be provided for every 250 cm^2 of hazardous operating areas.
- ❖ Atleast one 25/50/75 of DCP fire extinguisher shall be provided for every 750m2 of the hazardous operating areas.

Fire and Gas Detection Systems

Fire and gas detection system in all types of chemical industry is a must as the f rst line of defence against fire and explosion hazards. Detection and alarm systems provide prompt detection of a potential hazardous condition. At the same time, prompt detection provides time by notification of personnel, activation of automatic fire suppression and control systems during the early stages of an incident, thereby minimizing the impact of the fire.

A gas detector is designed to give a warning of the presence of flammable or toxic gases or vapours in air, well before they reach dangerous concentrations. Normally, the detector provides visible and audible alarm signals, but frequently it also performs a further action by imitiating control action such as increasing ventilation, shuting of sources of gas etc.

Fire detection system operates faster than the gas detection system. However both fire and gas detection system shall be considered in major chemical plants.

The areas in any chemical plant where gas and fire detectors should be provided with other details are stated below :

a) Gas Detection System

Spot type detectors should be installed is areas where there are potential leak sources like pumps, compressors, tank car and tank truck facilities, control rooms and air inlets in the vicinity of potential large flammable gas releases, ditches, trenches, sumps and other low points where heavy flammable vapours cloud accumulate. Gas detection systems should also be used for emergency functions like shut down of processes, activation of emergency ventilation etc.

The gas detectors should be located in accordance with the manufactures instructions. Regular checking of recorded callibration and maintenance is important to keep the system functional.

b) Fire Detection System

Fire usually begin small. Therefore specially in chemical factories dealing with highly flammable and combustible materials, it is very important to detect a fire as quickly as possible so that immediate action'can be taken. In case of a fire, the actions taken in the first minute are the most important to avoid a large fire with consequent injury to personnel and damage to equipment. In areas with low manning level (automated plant) automatic fire detection and alarm system is manditory.

The processing areas, storage areas, all pumping facilities, offices and other important areas alongwith ventilation and air conditioning ducts etc should be provided with automatic fire detection system and should comply with relevent local laws, regulations, guidelines and standards.

Some other Fire Protection Requirements

a) The foam water spray system comprising of foam induction unit in the distribution piping and foam water spray nozzles shall be provided in the areas and equipment where oil fire is expected, with local and remote (control room) operation.

   The fire safety assessment shall determine the required foam-water application rate and duration. Typically, an application rate of 6.5 to 7m3/min/m2 for the floor surface area to be protected, shall be maintained for duration of 30 minutes.

b) While designing gaseous extinguishing systems, the fire safety assessment shall determine the type of extinguishing agent, the spaces to be protected by each system and the methods of activating the system. Only extinguishing agents which do not have a negative impact on environment, non toxic to humans, and those who are not electrically conductive shall be applied in the system. Gaseous extinguishing systems are only effective in enclosed or semi-enclosed spaces of the plant.

   i) Carbon-dioxide system shall be provided for total flooding of enclosures such as those of gas turbines. The system shall be automatically activated by gas or fire detector and must have extensive safeguards built in to ensure the safety of the personnel present in the enclosure.

   ii) Inert gas system shall be provided to prevent the creation of flammable conditions inside equipment normally containing flammable products, such as vapour space of storage tanks.

   iii) Steam from the fixed steam system can be used to smaller fires, to dilute gas/ air mixtures in enclosed areas, to control flange fires in plants and on equipment handling flammable products at or above their auto-ignition temperature.

c) Some and heat venting system must be installed in the chemical plant specially at the process area, storage area and all other enclosed hazardous areas of the plant. The opening of these vents should be automatic with local or remote (control room) operation and should be independent of general electric power.

d) Explosion protection safeguards shall be provded the areas where flammable liquids and /or gases are stored and handled including combustible dusts in accordance with the standard norms and requirements for the system.

e) Sprinkler installation in high piled storage should be hydraulically balance with adequate water supply together with automatic roof venting. The sprinkler heads shall have adequate discharge for controlling fires.

f) Self contained breathing apparatus should be kept readily available for personnel safety as most of the chemicals on fire produce heavy smoke containing toxic gases such as carbon monoxide, hydrocyanic gases, nitro fumes etc. Operating personnel should be trained for use of breathing apparatus.

g) "No Smoking" and "Fire Orders" containing what to do incase of fire in large letters on a back ground of contrasting colours should be conspicuously displayed in all hazardous areas of the plant.

h) Boards indicating name and stock of flammable/hazardous materials should be displayed at places accessible from outside at all tanks and storage houses.

4.6 Passive Fire Protection Measures

Although adequate fire protection is provided in an installation, passive fire protection measures as indicated below should be adopted wherever required to minimise the chance of fire and also to restrict the spread of fire of the adjoing areas.

a) Fire proofing of structural members.

b) Spark arrestors and flame arresters.

c) Fire separation walls in concealed space/electrical substations/transformer yard / bays / cable galleries.

d) Fire seals in underground sewer system / flare knockout drum,

e) Impounding basins / dyke walls,

f) Lightening arrestor.

g) Pressurisation of enclosure.

h) Venting facilities of process equipment.

i) Electrical relays and fuses, earth leakage circuit breakers, neutral current circuit breakers.

j) Fire retardant coatings and tapes for cables.

k) Fire resistant low smoke (FRLS) insulation cables.

l) Flame proof and flame resistant electrical equipment and enclosure.