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IS 15394 (2003): Fire Safety in Petroleum Refineries and Fertilizer Plants - Code of Practice [CED 36: Fire Safety]

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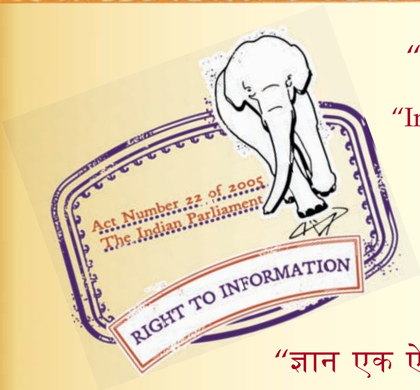

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पेट्रोलियम शोधन कारखानों और उर्वरक संयंत्रों में आग से सुरक्षा — रीति संहिता

Indian Standard

FIRE SAFETY IN PETROLEUM REFINERIES AND FERTILIZER PLANTS — CODE OF PRACTICE

ICS 91.120; 33.220.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards , after the draft finalized by the Fire Safety Sectional Committee had been approved by the Civil Engineering Division Council.

Despite the ever growing literature on prevention of fire and explosion hazards in petrochemicals, refineries and fertilizer plants, the occasional accident of fire or explosion is almost inevitable because there is inherent hazardous nature of the process itself. However, to prevent and reduce losses and injuries to human lives and property losses from fire and explosion emphasis are to be given on safe design and adequate fire protection measures. This safety code has, therefore, been formulated to give necessary guidance with regard to fire safety aspects of petrochemicals, refineries and fertilizer plants. Implementation of this Code would reduce the fire and explosion hazards of these plants and their associated tank farms utilities and other properties to a considerable extent.

Vulnerability of plant layout with respect to cyclone and earthquake may also be considered. For earthquake resistant design of structure, reference of IS 1893 : 1984 'Criteria for earthquake resistant design of structure (*fourth revision*)' shall be given. Entry/Exit point may be considered with respect to wind direction. Every layout must have two or three entry/exit points. Separate localized drain system should be provided for highly incompatible chemicals (if being handled in the same area). If emergency draining of any process equipment is designed, then control valve should be provided with instrument air/instrument nitrogen, which should be available during power failure.

Indian Standard

FIRE SAFETY IN PETROLEUM REFINERIES AND FERTILIZER PLANTS — CODE OF PRACTICE

1 SCOPE

This standard covers the requirements with regard to fire safety aspects of petrochemical plants, refineries and fertilizer plants.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards given below:

IS No.	*Title*
1239 (Part 1) : 1990	Mild steel tubes, tubulars and other wrought steel fittings — Specification: Part 1 Mild steel tubes (*fifth revision*)
2190 : 1992	Selection, installation and maintenance of first-aid fire extinguishers — Code of practice (*second revision*)
5572 : 1994	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation (*second revision*)
10221 : 1982	Code of practice for coating and wrapping of underground mild steel pipelines.
15325 : 2003	Design and installation of fixed automatic high and medium velocity water spray system — Code of practice.

3 PLANT LAYOUT

3.1 General

3.1.1 There should be at least 36 m of clear and open space between battery limits of adjoining process units. In case of ordinary hazards plants distance may be reduced to 20 m.

Block layout should be adopted as much as possible. The entire area should be sub-divided into blocks.

3.1.2 This clear area should not be regarded as reservoir of space for future expansion of units.

3.1.3 All blocks shall be surrounded by roads for access and safety. Alternative access should be provided for each facility for fire fighting and maintenance. Road widths and turning radii at road junctions shall be designed to facilitate movement of the largest fire-fighting vehicle.

3.1.4 The installation should have a secure perimeter, which may be of brick wall, having the specified height with, overhang carrying four rows of barbed wire or it can be any approved pattern such as chain link, etc.

It is normally kept around 3 m to 3.5 m high perimeter wall with barbed wire fencing of 0.6 m at top of the perimeter wall.

3.2 Spacing of Equipments Within a Unit

3.2.1 Spacing within battery limits between individual process equipment will depend on technological requirements.

3.2.2 There is no set formula for minimum spacing, as every unit will vary. However, hydrogen processes may require greater spacing than has been considered good practice in other types of units. For example, it has been calculated that fire temperatures in units processing oil will lie between 650 °C to 1 100 °C but may exceed 1 400 °C in units where hydrogen and light products burn in sufficient air.

3.2.3 Heaters should be located at one corner of the unit to limit the hazard of open flame to only the small part of the plant facing the furnace and also to facilitate fire fighting operations, the furnace should be at least 20 m away from the nearest process equipment handling hydrocarbon, with no sewer boxes, sampling points, etc., in between, from where hydrocarbon could emit vapours when the furnace is on. Individual heaters should preferably be 8 m apart.

3.2.4 Compressors should be at least 22.5 m away from fired heaters and preferably downwind and at least 8 m away from other process equipment which can act as source of ignition due to high temperature or otherwise. All compressors should have remote switches and valves.

3.2.5 As far as possible, pumps should not be compounded in a single area simply because they happen to fit or the arrangement appears more orderly. Except flange joints at suction and discharge of the pump there shall be no flange connections within the pump area, as well as no screwed connection. If any, screw connection is essential, it shall be track welded.

3.2.6 Air fin coolers should be installed above pipe rack. Pumps handling hydrocarbons and materials above 230°C should not be installed underneath the air fin coolers. Electrical cable must be underground, except where connection is to be made, exposing it most minimum.

3.2.7 Consideration should be given to the use of water filled equipment such as condensers, etc, as 'heat shields' between easily damaged equipment and the heaters of pumps which are most fire prone.

4 PIPE RACKS

4.1 It is accepted practice for a pipe rack for an individual unit to run down the centre of that unit, thereby splitting it into two or more areas of equipment layout. It should be understood that each of these individual pipe racks will probably feed into at least one large inter-unit pipe rack which will probably carry major hydrocarbon lines, power cables, flare lines, etc. Pipe racks shall not be less than 3 m high from ground. The vertical and horizontal pipe supports shall be given fire resistance treatment to withstand 2 h fire exposure and constructed of 50 mm thick concrete or equivalent fireproof materials.

4.2 Major pipe racks shall be laid away from process equipment to avoid fire exposure to overhead pipe rack due to failure of vessel or equipment. Such pipe racks shall depend on technological requirements and shall be at least 5 m from any process equipment or vessel with hydrocarbon service. If crossed over road, these shall be at least 6 m high and protected against mechanical damages that is by passing cranes, fire appliances, etc.

5 TANKAGE

5.1 No other tankage except day tanks shall be provided within battery limits of any process units.

5.2 Accumulators or similar vessels with large liquid hold-ups should be reduced to a minimum and installed at ground, if possible in the battery limit.

5.3 Adequate drainage should be installed around any such vessels.

5.4 When these are installed above ground, they should be in the most open areas possible, preferably at the battery limits.

6 CONTROL ROOMS

6.1 Control room buildings located in hazardous areas shall be blast resistant type. Such building should not be located within 15 m for single process units and 30 m for 2 or more process units. Blast resistant construction should be required for control rooms for light hydrocarbon processing/storage facilities and units handling hydrogen located within 120 m. Beyond 120 m control room need not be blast resistant type.

Blast resistant control room should be designed for static over pressure of 3 MPa. Type of construction shall be decided after appropriate risk evaluation.

Minimum two exits shall be provided in such a way that each has different un-obstructed escape route. Blast resistant construction baffle wall shall be provided at opposite entry doors to contain blast and it shall have 45°/90° overlap on both sides.

Control room should be single storeyed with no equipment on roof, location of control room should be on periphery of the plant. At least one side on the control room should be adjacent to road or parking area. Control room should not be enclosed by equipment from all sides. Control room should not be located on lower level than surrounding plant/ tank farm. Blast resistant control room should be designed for static over pressure of 3 MPa. Type of construction shall be decided after appropriate risk evaluation. Its plinth should be higher from surrounding plant level.

Exhaust gas tubing of toxic /inert gas analysers should not be kept inside control rooms.

6.2 The air intake for the pressurization system should be carefully selected to assure a continuous supply of clean fresh air not contaminated by hydrocarbon gases or vapour. Gas detection devices should be installed in the intake air stream to sound an alarm upon detection of hazardous gas concentration in excess of 25 percent of the lower explosive limit and to shut down the pressurization facilities upon detection of concentration in excess of 60 percent of the lower explosive limit.

6.3 Hydro-crackers and hydrotreaters have incurred explosion losses with explosive effects to such higher degree than has been experienced by the more familiar processes. Thus, blast protection is of far greater importance for the control houses of these units or for central control houses of plants employing these units. Again, the high value, importance and long replacement time of the control equipment within are major factors in demonstrating the need for blast protection.

Blast damage results from an atmospheric over pressure imposed on the building by blast wave. While the mechanics of blast wave effect are quite complex, we are concerned here with the simple effect of the blast wave striking directly upon and perpendicular to the exposed wall of the building.

We must determine the approximate energy potential of an explosion occurring in a vessel within the process unit. Having determined this, we can then calculate the peak overpressure on the building at very long distances from the blast centre. Peak over pressure and distance will determine the degree of protection needed and the means of achieving it.

6.4 The distance between control building and process unit shall be 15 m minimum. Serious consideration should be given for maintaining 30 m of distance as greater distance reduces exposure to fire, makes it far less likely that flammable vapour clouds will be ingested by the pressurizing air intake and reduces the probability of shrapnel damage.

7 BLAST RESISTANT CONSTRUCTION

7.1 Having established a distance from process equipment to the control house, the peak over pressure at the building can be calculated. This peak over pressure will determine the type of blast resistant construction required to maintain building integrity.

7.2 Windows should be minimized if not eliminated. Opening through walls shall not exceed 7 percent of wall area. Glass used for windows shall be toughened glass or shatter proof of 7 kgf/cm^2 rating.

7.3 Asbestos sheets, corrugated steel, or aluminium panels will fail at over pressure under 15 kg/cm^2. Increased panel strength only leads to failure of the supporting structures.

7.4 Non-reinforced concrete or cinder block walls will shatter at over pressures in the 15-22 kg/cm^2 range.

7.5 By judicious siting of a control house with regard to other massive but less hazardous equipment, the probability of a blast wave impinging directly on the building may be significantly reduced.

7.6 Where space limitations do not permit adequate distance and the building exposed by the most hazardous process equipment, an alternate method of shielding is to erect a reinforced concrete blast wall. When this method is used, care should be taken to ensure that a gas trap area is not formed between the wall and the building. Sensing equipment should be provided or ventilation should be provided.

8 PUMP AND COMPRESSOR HOUSE

8.1 There is a trend toward constructing gas compressor shelters with open sides. However, if gas compressor buildings or any other vapour hazard buildings are full enclosed, they should have abundant fresh air ventilation. Pump and gas compressor used for hydrocarbon service shall be located at a free-ventilated area and housed in asbestos and steel frame constructed with free ventilation at the floor level in all direction to prevent accumulation of flammable vapour.

8.2 Most hydrocarbon vapours are heavier than air, the vapour tend to collect at floor level and therefore part of the ventilation must be from the floor level. If there are basements or floors depressed below ground level it may be necessary to install a forced ventilation system to maintain a continuous flow of fresh air.

8.3 An accumulation of flammable vapour or a fire within the confining shelter will make it impossible to shut down pumps and compressors locally and to block in lines. A remote shutdown stations for drivers should be provided and remote blocking valves provided on any lines capable of flowing flammable liquids into the fire area. Remote control switches and valves for suction for pump and compressors housed shall be provided in case of vapour release or fire. This system will be connected to audible alarm.

8.4 It is recommended that gas detection devices be installed in buildings. These devices should be arranged to activate an alarm and shut down compressor facilities upon sensing gas concentrations exceeding a permissible limit. It is preferable to activate water spray system simultaneously with alarm.

8.5 Since any enclosure will tend to concentrate a fire, special consideration should be given to water protection. Water spray systems capable of delivering at least 0.86 m^3/h/m^2 are recommended. Monitor nozzle should be located for unrestricted coverage of the sheltered equipment.

9 FIN FAN UNITS

Air-cooled fin fan units should not be installed at elevated locations above pipe racks or other process equipment. Experience has indicated that any such multi-level stacking can increase the extent of damage in the event of fire.

Excessive vibration shutdown devices should be installed on fin fan coolers.

10 UTILITY BUILDINGS

Utility buildings such as laboratories, small workshop steam, power generation, air compression facilities and warehouses should be spaced at a minimum of 30 m from process unit. These buildings should be constructed of fire resistive construction. Consideration should be given to potential blast energies when planning for buildings, which may be exposed by process units.

11 DRAINAGE

11.1 Effluent channels should be covered within battery limit and flame-trapped in and around plants handling flammable liquids or liquefied gases. Effluent channel cover should be fire rated for at least 1 h.

The ground should be sloped so that oils accidentally released by rupture or failure of piping or equipment can drain out of the area with a minimum of exposure to other process equipment.

11.2 Fire stops or water seals should be provided throughout industrial sewer or drainage ditch systems to prevent vapour spread that can be released from openings in vulnerable areas. Sealed section of sewer systems should be vented at suitable points to prevent pressure build-up and the blowing of seals if light materials enter the system. The sealing and venting of such systems is of particular importance where drains from a building are connected to an industrial sewer system.

11.3 Sewer systems, if provided, should be sized not only for normal runoff, but also for the possible over capacity required for disposal of water that may be applied during fire fighting operations.

Storm water and process drain together are not recommended. System should drain process liquids to safe location.

Adequate slope should be provided from centre of the unit to the perimeter both in longitudinal and latitudinal directions.

Separate localized drain system should be provided for highly incompatible chemicals (if being handled in the same area).

If emergency draining of any process equipment is designed, then control valve should be provided with instrument air/instrument nitrogen which should be available during power failure.

12 STORAGE TANK

12.1 Particular attention should be given to the selection of a storage tank area. Most hydrocarbon vapours are heavier than air; therefore, tankage should preferably be located down grade from plant process areas. The direction of prevailing winds should also receive consideration in order to minimize the possibility of released vapours drifting through the plant. Similar consideration will be given to the piping lay out. All storage tanks should be provided with fixed foam installation and water spray cooling system.

Fixed spray system should also be provided for the following:

a) Pumps handling products close or above their auto ignition temperatures,
b) Pumps handling lighter products,
c) Pumps handling other Class A petroleum products which are located under air cooled heat exchangers or critical flanged connection,
d) Compressors handling lighter products which are not installed in enclosures and can not be covered by static manually operated monitors,
e) Vessels, columns and exchangers normally holding a liquid volume of lighter products of more than 5 m^3. Vertical vessels and columns shall be fully sprayed upto a height of 15 m above the potential source of fire, excluding the skirt, and
f) Uninsulated vessels normally holding 10 m^3 or more of Class A and B petroleum products.

12.2 LPG bullets/spheres and flammable/combustible oils/liquids storage tanks (except day tanks attached to plants), should be detached from all other properties by the minimum spacing requirement laid down in Annex A.

12.3 Layout of groups of horizontal pressure storage tanks should be such that the longitudinal axis does not point toward vital process areas, or important high values structures. Experience has shown that tanks may rupture under fire conditions and move considerable distance along their longitudinal axis due to the rocket effect. If aimed into vital plant areas, such tanks present serious loss possibilities.

12.4 The relevant accepted codes should be followed as standards for storage tank construction. Welding is the preferred means of construction. Bolted/Rivetted tanks are undesirable and should be avoided. Under no circumstances bolted tanks ever be used for low flash point (below 65°C) products, because it is virtually impossible to keep them properly gas tight.

12.5 Tanks for storage of low flash point products should be of the standard cone top (weak roof seam), floating roof or standard pressure types.

12.6 If the flammable vapours are vented from a tank during breathing or filling, pressure vaccum (PV) vents are frequently used for vapour conservation. The potential flame propagation into a tank through an approved PV vent has proved to be negligible. Thus, flame arrester installed in conjunction with PV vents serve no purpose. No-freeze type PV vents should be considered for use in freezing climates to avoid tank failure because of pallet sticking. Also one stand by PV vent valve should be provided for 100 percent capacity.

12.7 Special attention should be given to the possibility of static ignitions. Proper counting should be provided and suitable protection against lightening should also be provided. The filling pipe shall be above the suction pipe of the tank in order that suction pipe is submerged in liquid. (The rate of filling in vapour space is 1 m per second. This applies to all filling operations for example, operating equipment, tank cars, tank trucks, etc. However, this does not form a standard as such).

NOTE — Conditions under which static ignition can occur, as well as the methods to prevent static ignition are described in American Petroleum Institute PR 2003; Protection Against Ignitions Arising Out of Static, Lightening and Stray Currents.

12.8 All around the tank farm area, suitable road approaches of 6 m wide should be provided for free movement of fire fighting vehicles for event of any emergency.

12.9 A valve to shut off in case of damage to such water piping shall be provided outside the dyked area at a safe location to isolate each storage tank. The valves must be accessible in case of a fire.

12.10 All pressure storage tanks should be equipped with individual relief valves. Relief should preferably be mounted directly on the tank with no block valves between the relief and the tanks, unless the relief valves provided in duplicate and so valved that one will always be left in service. If block valves are installed beneath individual relief valves, they should be chained and locked or sealed in the open position to prevent unauthorized closing.

12.11 Supports of elevated horizontal tanks should be of concrete or solid masonry construction. Steel leg supports of spherical tanks should also be protected to their full load-bearing height in manner which affords fire resistance rating of not less than 2 h. However, 3 h rating would be preferable.

12.12 All tanks or groups of tanks containing hydrocarbons at atmospheric pressure, should be located in dyked enclosure of earthen, concrete or solid masonry. Aggregate capacity of tanks located in one dyke shall not exceed 120 000 m^3 in case of floating roof ranks and 60 000 m^3 for fixed roof tanks.

Dyked enclosure should be capable to contain the complete contents of the largest tanks within the dyke. Dyke height shall not be less than 1 m and shall not exceed 2 m.

Dyke should withstand maximum hydrostatic load that can generate due to release of tank contact. Wherever practical dyke height should be restricted to 2 m for flammable liquids/gases, there should not be any flange joint inside the dyke.

12.13 Pressure storage vessels should be arranged into groups each having a maximum of 6 vessels. Capacity of each group shall be limited to 15 000 m^3. Any vessel in one group shall be separated from a vessel in another group by a minimum distance of 50 m. If multiple rows are needed the tanks should be staggered in such manner as to lessen the chances of any tank rocketing into another. If horizontal pressure tanks (bullets) are separated individually by concrete walls with overhead water-sprays, then distance separation by 50 m can be reduced to the diameter of the adjacent horizontal tanks.

12.14 The ground beneath horizontal tanks should be sloped so that any accidental release of liquids will flow from beneath the tanks. At least diversionary diking should be provided to direct liquids away from involved tankage to a safe location. Where this is not practical, then full diking of groups of tank batteries is needed.

12.15 For spherical pressure storage tanks the diking requirements, including the capacity limitations as outlined for atmospheric tanks, should be followed. The ground beneath the spheres should be graded so that any liquid products released will drain from beneath the tanks to a collection basin within the enclosing dyke. The basin should be removed as far as possible from the sphere.

12.16 Loading racks for trucks or rail tankers should be located at a minimum distance of 30 m from storage tanks, and at least 60 m from gas compressor houses or gas processing areas. Loading racks should be equipped with static grounding on bonding devices, preferably arranged so that loading can not be accomplished until positive bonding between the tank vehicle and the loading racks has been established. Spillage from the tanks should be allowed to drain into pits. Pits shall lead the collected liquid away from the load rack area.

12.17 Excess flow valves should be provided in the loading piping, just ahead of the connection where the loading hose joins the rigid piping. Loading arms should preferably be provided in place of hoses.

12.18 Pump shut down switches should be located remote from both the loading racks and the storage area so that they will be readily accessible in case of any emergency arises in either of these areas.

12.19 Experience has indicated time and again that unprotected steel supports of storage tanks, towers, vessels, heaters, piping and other process equipment fail rapidly when subjected to the severe temperatures generated by a liquid hydrocarbon or gas fire. For this reason all load bearing supports in the primary exposure areas must be protected to their full load bearing height by fire resisting material having a 3 h protection rating preferably of 3 h.

12.20 This should be specified as all load bearing vertical structures are to be fire-resisting treatment for 2 h rating (50 mm thick concrete or any other materials upto the point where the load is transferred to horizontal supports).

12.21 Similarly, the operating vessels on ground shall have brick and concrete skirt with openings for cross ventilation (to prevent vapour accumulation). It should be further noted that reinforced concrete or other solid masonry supports of at least 200 mm thickness have a fire resistance rating equal to or higher than a 3 h rating restrict the temperature of the metal being protected to 538 °C or less, under fire exposure conditions of 982 °C for 3 h.

12.22 The primary exposure areas in gasoline plants where fire resistance with 3 h rating is required as follows:

a) Supports of all horizontal and spherical product storage tanks.
b) Supports of all fired heaters elevated above ground.
c) Tower skirts should have fire resistance protection on the outside, but need not be fire resistance on the inside if both of the following conditions are met:
   1) There are no breakable pipe joints and no valves installed inside the skirt, and
   2) There is only one access opening in the skirt not greater than 450 mm in diameter. The conditions of this item can be met by closing all except one 450 mm diameter access opening with 6 mm steel plate.
d) Supports of vessels such as receivers, accumulators, reboilers, large heat exchangers and similar vessels with considerable liquid hold-up capacity should have fire resistance protection to their full load bearing height. This applies to such vessels even if they are installed in elevated structures or at elevated locations above pipe racks.

12.23 For fire resistance of pipe rack supports, some individual analysis is required:

a) In general, both the vertical and horizontal members of the first level of pipe racks located within 7.5 m of heaters, hydrocarbon pumps, towers and major vessels should be protected by fire resistance having a 3 h rating. Such pipe rack supports located over 7.5 m but within 15 m of major equipment as outlined, should be protected by fire resistance treatment having a 2 h rating. Pipe rack supports beyond 15 m from major equipment normally would require fire resistance unless unusual conditions of exposure of loading exist. The pipe rack should not be of cantilever type.
b) If fin fan coolers are installed above pipe racks, the upper levels of the pipe racks above the first level as well as the legs of the fin fan coolers should be protected to their full load bearing height with fire resistance having at least a 2 h rating.
c) Vessels with large liquid hold-up should not be installed above pipe racks. If under unusual circumstances such vessels are installed above pipe racks, then fire resistance with 3 h rating should be provided to the full load bearing height of the vessel supports including all levels of the pipe rack supports.

13 ELECTRICAL EQUIPMENT

13.1 Building in hazardous areas as defined in IS 5572 shall have no electrical equipment arcing or sparking for example, Air-Conditioner, office calculators, data recorders, telephones, etc. Unless these are flame-proof. Alternately, such building housing shall be pressurized with clean air as per **6.2**.

13.2 If electrical power is generated on the premises, the generating equipment and its drivers should be detached at least 30 m from gas hazardous areas. Electrical substation switching equipment if within 15 m of gas hazardous areas should be installed in pressurized buildings. Often it may be less costly to place sub-station transformer and switching equipment at safe distances from hazardous areas rather than make an installation conforming to the code requirements within the hazardous area. Within the process area it is most desirable to have all electrical circuits placed in underground conduits. Electrical conduits carried overhead on pipe racks within process areas are quite vulnerable to extensive damage in the event of fire.

The electrical power distributing system within the plant compound should be completely buried underground excepting for final connections to motors and lighting fittings. It would be permissible however, to lay cables in underground cable trenches, provided they are either completely filled with sand or provided with concrete baffles at not more than 45 m interval.

13.3 Emergency power supplies system should be provided for adequate supply of power to all emergency lighting and motive power to essential cooling water, fire pump and other equipment required for safe shut-down of the plant.

14 FIRE PROTECTION ARRANGEMENTS

14.1 Each industry shall have different type of fire organization to meet its particular need because of variables in size, available manpower, nature of operations, and facilities available. Fire fighting crew must be maintained round-the-clock to man the fire appliances.

14.2 Extinguishers

14.2.1 The first line of defence for extinguishment is to have readily available an adequate number of fire extinguishers of the proper type for the given class of fire in accordance with IS 2190.

14.3 Water Supply

14.3.1 Water supply is the back bone of fire fighting operations in hydrocarbon processing plants, chemical factories and fertilizer plants. The reliable water supply should, therefore, have following characteristics:

a) Instantaneous availability at all the points in the plant area;
b) Enough quantity;
c) Sufficient pressure;
d) Reliability; and
e) Continuity.

14.3.2 The source of fire water should be preferably arranged from perennial source such as lake or river, etc.

14.3.3 Capacity of storage of fire-water should be worked out on the basis that water supply should be available for a period of 9 h of fire fighting for full installed pumping capacity. Use of sea water as backup and flushing arrangement may be allowed.

14.3.4 While calculating the quantity of fire-water due allowance should be given for reliable sources of make-up water to the storage facility.

If pump house is underground adequate number of drain pumps with guaranteed power supply be ensured to avoid flooding of the pump area. All sectional valves should be raising spindle type with easy identification (closed or open). Alternatively butter fly valve be provided. Location should be such that in case fire/explosion, it can not get damaged.

14.3.5 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.

14.4 Fire Water Pump and Fire Water Mains

14.4.1 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.

14.4.2 In case of large size of industry, two major fires to be fought at one time is to be presumed to work out the pumping capacity.

14.4.3 Fire-water pump/pumps should be of such a capacity that it will continue to supply water for fire fighting at the rated capacity without any interruption at a minimum pressure of 7 kg/cm^2 even to the farthest point. However, minimum capacity of fire-water pump should be 410 m^3/h at 8.8 kg/ cm^2 pressure.

Sum of the two of the largest flow rates calculated for different sections as shown below shall be taken as design flow rate:

a) Fire-water flow rate for tank farm/sphere/bullet areas shall be aggregate of the following:
   1) Water flow calculated for cooling a tank on fire at a rate of 10 lpm/m^2 of tank shell area;
   2) Water flow calculated for all other tanks falling within a radius of (R + 30) m from centre of the tank on fire and situated in the same dyke area, at a rate of 5 lpm/m^2 of tank shell area;
   3) Water flow calculated for all other tanks falling outside a radius of (R+30) m from centre of the tank on fire and situated in the same dyke area, at a rate of 3 lpm/m^2 of tank shell area;
   4) Water flow required for applying foam into a single largest cone roof or on a floating roof tank (after the roof has sunk) burning surface area of oil by way of fixed foam system, where provided, or by use of water/foam monitors; and
   5) Fire-water flow rate for supplementary stream, shall be based on using 4 single hydrant outlets and 1 monitor simultaneously. Capacity of each hydrant outlet as 36 m^3/h and of each monitor as 144 m^3/h may be considered at a pressure of 7 kg/cm^2.
b) Fire-water flow rate for LPG sphere storage area shall be aggregate of the following:
   1) Water flow calculated for cooling LPG sphere on fire at a rate of 10.2 lpm/m^2 of sphere surface area,
   2) Water flow calculated for all other

spheres falling within a radius of (R+30) m from centre of the sphere on fire at rate of 10.2 lpm/m^2 of surface area,

3) If the water as calculated above works out to be more than 2 000 m^3/h the layout of the sphere should be reviewed,

4) Water flow for supplementary hose stream shall be considered as 288 m^3/h as indicated under item (a), and

5) The sphere should be laid in two separate groups with each group limited to a maximum of 6 spheres. The groups shall preferably be separated by a distance of (R+30) m.

c) Fire-water flow rate for LPG loading racks/ filling sheds shall be determined by the area of 3 largest adjacent zones controlled by different alarm valves at a rate of 10.2 lpm/m^2 plus 288 m^3/hr supplementary hose stream protection.

d) For LPG pump/compressor house, the minimum spray density will be 20.4 lpm/m^2.

e) Fire-water flow rate for plant area shall be determined by the area of largest plant battery. Flow rate shall be taken at a rate of 1 lpm/m^2 of such plant battery plus 288 m^3/h for supplementary hose stream protection.

14.4.4 Pump drivers should preferably be electrical driven with same number of stand-by diesel driven (pumps). Alternatively emergency power supply can be supplied to part of the pumps.

14.4.5 The suction and discharge valves of fire-water pump(s) must be kept open at all times and the discharge line shall be kept under pressure by another water source with a non-return valve against backflow. A starting device for fire pumps shall be provided as soon as the discharge pressure drops to half the rated discharge pressure of the fire pump. In case of two or more such fire pumps, such starting devices shall be individually set at a pressure drop of 45 percent to 55 percent of rated discharge pressure in order that on each successive drop next fire pump will start automatically by the device.

When the suction source comes under a positive head from an open source such as pond, protection shall be provided against the passage of materials, which might clog the suction in-take. These screens shall be so arranged that they can be cleaned without disturbing the suction pipe. A re-circulation line into the pond may be provided for carrying out performance tests of pump.

14.4.6 Fire-water mains should be designed of sufficient size, to be capable of delivering rated fire-water pumping capacity to the main process area at a residual pressure of 7 kg/cm^2.

14.4.7 Fire-water distribution shall be through a ring main with block valves to isolate only one section for repair/maintenance. The main shall be laid underground with carbon steel pipes with suitable protection against corrosion and duly protected below reads against damages by moving automotives. In case of steel pipe [*see* IS 1239 (Part 1)], it shall be protected against external corrosion or mechanical damages as well as the hydrant above ground.

14.4.8 Fire mains should be a minimum of 150 mm in diameter.

14.4.9 Fire mains should preferably be of mild steel or cast iron pipes. In case of mild steel pipe-lines precautions against internal and external corrosion are required to be taken alongwith cathode action in pipes due to earthing of welding units. Normally protection against external corrosion is given as per IS 10221.

14.4.10 No pressure regulating valve should be permitted except where absolutely necessary.

14.4.11 The system must be buried such that the top of the pipe is not less than 1 m below the ground level and masonry or equivalent supports shall be provided at regular intervals.

14.4.12 All fire mains within the plant compound must be buried underground. However in exceptional cases it would be permissible to lay such portions of the main above ground which are at least 15 m away from plant battery limit or other property.

14.4.13 All underground mains should be of close circuit in preference to dead end mains.The underground lines laid should be a minimum 5 m away from process/storm water channel so that seepage does not affect the piping.

14.4.14 Sectional valves should be installed so that portions of the underground main system can be taken out of service for repairs without undue interruption of the fire-water protection.

The underground valve pit housing should be of RCC/ brick construction. The pit should be spacious enough to carry out regular maintenance. Rung/Ladder is to be provided for access to and from the pit. The pit chamber should have a proper covering and this should be 20 cm above datum level to prevent rainwater ingress into the pit.

Criteria for providing isolating valves to be specified should be such that at least 50 percent of the hydrants are available on line when such isolation occurs from each equipment.

14.4.15 Mains shall not be laid under buildings or, large open storage or rail roads and roads carrying heavy traffic.

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

14.4.17 Standard fire hydrant with two outlets for hose connections of 63 mm size should be installed with not greater than 30 m spacing between the fire hydrants. At least one fire hydrant with a pump suction connection should be located on each side of the process block and areas of special hazards.

The distance requirement between hydrants can be relaxed to 45 m for utilities plant, auxiliary buildings and relatively less hazardous plants like AS-DAP, etc.

14.4.18 It is most desirable to install fixed water monitors for protection of process areas and certain special hazards. Monitors can be placed into operation quickly by one man, and once they are set in a given position, he is free to perform other duties as may be required by the emergency.

14.4.19 For effective reach of water from the fixed monitors for protection of a process area the spacing between monitors and process area should be approximately 22.5 m. However, final spacing and location should be determined by the layout and arrangement of the equipment to be protected.

14.4.20 Monitors and fire hydrants should not be closer than 7.5 m for plant equipment, buildings or structures.

14.4.21 Supply line to each fixed water monitor should be of 150 mm size and for the hydrant of 100 mm size.

14.4.22 In case of multi-storied buildings, satisfactory access shall be provided to all parts of each floor by means of incombustible internal or external staircases. Normally, a minimum of two such staircases will be needed per compartment, but in case the area of the compartment exceeds 2 000 m^2, an additional staircase shall be provided for every additional 1 500 m^2 or part thereof.

On the other hand, if a compartment has a floor area of less than 500 m^2, one access staircase shall be acceptable. The access staircases shall be located such that, as far as possible, no part of each floor is more than 30 m, from the nearest staircase. Where it is not possible to locate the staircase in the aforesaid manner, alternative methods for protection of such large upper floor may be adopted. External access staircases shall be open to sky.

15 FIXED FIRE PROTECTION INSTALLATION

15.1 All fixed roof type hydrocarbon storage tank shall be provided with fixed foam installation either for top application or base injection system.

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

15.3 Storage spheres and bullets holding liquified gaseous hydrocarbons whether insulated or uninsulated shall be protected with well designed water spray system. Standard rate of application of water is 0.61 $m^3/h/m^2$.

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

15.5 High pressure and high temperature pumps, especially those essential to process operation and/or where they are located close to other critical equipment, fixed water spray system should be provided and the rate of application shall be 1.23 $m^3/h/m^2$. Each installation should be given individual consideration in determining the area of application.

15.6 Highly exposed critical pipe racks, value manifolds, control equipment shall also be protected with water spray system. The rate of application should be 0.61$m^3/h/m^3$.

15.7 General considerations for the design of fixed water spray or deluge system include:

a) Systems shall be automatic in operation wherever practical, especially on the more critical hazard areas;
b) Maximum delay in actuation should be 30 s;
c) Lever operated gate valves and quarter turn plug valves shall not be used;
d) Nozzle of spray heads shall not be more than 0.6 m away from the surface to be protected;
e) Area drains shall have capacity equal to maximum discharge rate of water spray system;
f) Total possible water demand for plant water spray systems shall not exceed 50 percent of fire water pumping capacity;
g) Hydraulic calculations of the water spray system shall be in accordance with relevant Indian Standard; and
h) Systems shall be thoroughly inspected and tested, including cleaning of strainers and area drains at least every six months.

15.8 Individual plants require individual treatment for fire protection with steam systems as much as the process system. The aspect has to be given due consideration during the initial design stages.

15.9 Steam rings are heater/reactor transfer lines, reactor/exchange transfer lines and for feed/effluent exchanger flanges.

15.10 Nitrogen is also used for purging purposes and blanketing to prevent the fires. This aspect has also to be given due consideration during the initial design stages.

ANNEX A

(*Clause* 12.2)

GENERAL RECOMMENDATION FOR SPACING

A-1 The distance between plants stipulated hereunder is the distance obtained by taking measurements between the outermost points of the two nearest equipments located in the adjoining plants. For this purpose the pipe racks may be ignored.

A-2 In case of plants being located in a building, measurement are to be taken from its external wall to the nearest equipment/external wall of the adjoining plant.

A-2.1 For storage vessels the following distance is to be taken from the boundary wall/dyke wall:

a)	Between inter plants	: 20 m
b)	Between plant and tankage	: 25 m
c)	Between plant and liquified/ pressurized hydrocarbon spheres or bullets	: 50 m
d)	Between plant and utilities, auxiliaries, miscellaneous buildings and stacks in open	: 15 m
e)	Between tankages and liquified / pressurized hydrocarbon spheres/bullets	: 25 m
f)	Between tankages and utilities auxiliaries, miscellaneous buildings and stacks in open	: 15 m
g)	Between two tanks	: 15 m or diameter of larger tank whichever is more
h)	Between liquified/pressurized hydrocarbon spheres / bullets and utilities, auxiliaries, miscellaneous buildings and stacks in open	: 50 m

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