IS 15325 (2003): Design and Installation of Fixed Automatic High and Medium Velocity Water Spray System - Code of Practice [CED 22: Fire Fighting]

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भारतीय मानक

जड़ित, स्वचलित उच्च एवं मध्यम गति की जल फुहार प्रणालियों के डिजाइन और संस्थापन की रीति संहिता

Indian Standard

DESIGN AND INSTALLATION OF FIXED AUTOMATIC HIGH AND MEDIUM VELOCITY WATER SPRAY SYSTEM — CODE OF PRACTICE

ICS 13.220.10

BUREAU OF INDIAN STANDARDS
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FOREWORD

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

The term 'Water Spray' refers to the use of water in a form having a pre-determined pattern, particle size, velocity and density discharged from specifically designed nozzles or devices.

Water spray systems are usually applied to special fire protection problems since the protection can be specifically designed to provide for effective fire control, extinguishment, prevention or exposure fire protection. These systems may be independent of or supplementary to other forms of protection.

Water spray systems are most commonly used to protect processing blocks, processing equipments, structures, flammable liquid and gas vessel, piping and equipment such as transformers, oil switches and some combustible solids, cable trays, cable racks, etc.

In situations where oil and flammable liquids are stored and/or used in such quantities and in such manner that the value of the standard sprinklers in the event of fire is open to question, medium and/or high velocity sprayers may be employed *in lieu* of or in conjunction with sprinklers. This Code is intended to provide a guide as to when such systems should be installed, details of their design and performance.

The purpose of the Code is to provide minimum requirements for fixed water spray systems based upon sound engineering practices. While formulating this Code, considerable assistance has been derived from the Tariff Advisory Committee.

This Code is intended to cover water spray protection from fixed nozzles only. The design of specific systems may vary considerably depending on the nature of the hazard and basic purpose of protection. Because of these variations and other environmental factors, the systems must be competently designed, installed and maintained. The designer must thoroughly understand the capabilities and limitations of the protection.

High velocity nozzles can be expected to extinguish fires involving liquids with flash points of 65°C (150°F), or higher and should be installed where such flammable fluids constitute the hazard. For fluids flashing at below 65°C (150°F), extinguishment is always not possible or even desirable and for these, medium velocity water sprayers need to be installed to provide cooling, controlling the burning and/or exposure protection.

There are also limitations to the use of water spray systems such as slop-over or frothing hazard where confined materials at a high temperature or having a wide distillation range are involved. Similarly, water reacting chemicals, such as, metallic sodium and calcium carbide, etc, produce violent reaction or liquefied gases at cryogenic temperature which boil violently in contact with water.

Experiments have proved that the rule for the exposure protection contemplate emergency relieving capacity for vessels based upon a maximum allowable heat input of 16 290 k.cal/h/m^2 (6 000 BTU/h/sqft). In other words, it is expected that the heat input rate to the contents of an unprotected tank will be reduced from in excess of 54 300 k.cal/h/m^2 (20 000 BTU/h/sqft) to something of the order of 16 290 k.cal/h/m^2 (6 000 BTU/h /sqft) for a water sprayed tank. Similarly, the tank shell temperature which shall not preferably exceed 343°C (650° F), can be brought down to 100°C (212° F) by water spray system.

The Committee responsible for the formulation of the standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN AND INSTALLATION OF FIXED AUTOMATIC HIGH AND MEDIUM VELOCITY WATER SPRAY SYSTEM — CODE OF PRACTICE

1 SCOPE

This Code deals with the provisions of automatic water spray systems and installations in premises. It also covers the essential water supplies and their maintenance.

2 REFERENCES

The standards given in Annex A 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 indicated at Annex A.

3 TERMINOLOGY

For the purpose of this Code the following definitions shall apply.

3.1 Water Spray System — A special fixed pipe system connected to a reliable source of fire protection water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface or area to be protected. The piping system is connected to the water supply through an automatically actuated deluge valve which initiates flow of water. Automatic actuation is achieved by operation of automatic detecting equipment installed along with water spray nozzles. There are two types of systems namely high velocity and medium velocity systems.

3.2 Spray Nozzle — A normally open water discharging device which, when supplied with water under pressure will distribute the water in a special, directional pattern peculiar to the particular device.

Nozzles used for high velocity water spray systems are called 'Projectors' and nozzles used for medium velocity water spray systems are called 'Sprayers'. Both these nozzles are made in a range of orifice sizes with varying discharge angles so that discharge can be controlled for optimum protection.

3.3 Deluge Valve — A quick opening valve which admits water automatically to a system of projectors or sprayers and is operated by a system of detectors and/or sprinklers installed in the same areas as nozzles.

3.4 Control of Burning — Application of water spray to equipment or areas where a fire may occur to control the rate of burning and thereby limit the heat release from a fire until the fuel can be eliminated or extinguishment effected.

3.5 Exposure Protection — Application of water spray to structures or equipment to limit absorption of heat to a level, which will minimize damage and prevent failure, whether source of heat is external or internal.

3.6 Impingement — The striking of a protected surface by water droplets issuing directly from projectors and/or sprayers.

3.7 Run Down — The downward travel of water along a surface caused by the momentum of the water or by gravity.

3.8 Slippage — The horizontal component of the travel of water along the surface beyond the point of contact, caused by the momentum of water.

3.9 Insulated Equipment — Equipment, structures, vessels provided with insulation, which for the expected duration of exposure, will protect steel from exceeding a temperature of 454°C for structural members and 343°C for vessels.

3.10 Density — The unit rate of water application to an area or surface expressed in l/min/m^2.

3.11 Automatic Detection Equipment — Equipment which will automatically detect one or more components directly related to combustion such as heat, smoke, flame and other phenomenon and cause automatic actuation of alarm and protection equipment.

3.12 Fire Barrier — A fire barrier is a continuous wall or floor that is designed and constructed to limit the spread of fire.

3.13 Range Pipes — Pipes on which sprinklers are attached either directly or through short arm pipes which do not exceed 300 mm in length.

3.14 Distribution Pipes — Pipes which directly feed the range pipes.

4 COMMON REQUIREMENTS TO HIGH VELOCITY WATER SPRAY AND MEDIUM VELOCITY WATER SPRAY SYSTEMS

4.1 Water Supplies

4.1.1 Water for the spray system shall be stored in any easily accessible surface or underground lined reservoir

or above ground tanks of steel, concrete or masonry.

4.1.2 Common reservoir/tank for all other systems such as sprinkler installation and hydrant system as well as spray systems are acceptable provided:

a) All the suction inlets or foot valves are at same level, and

b) Aggregate capacity of the reservoir is equal to the total requirement of all the systems put together.

4.1.3 Reservoirs/tank of and over 225 m^3 capacity shall be in two independent but interconnected compartments with a common sump for suction to facilitate cleaning and repairs.

4.1.4 Water for the system shall be free of particles, suspended matters, etc, and as far as possible, filtered water shall be used for the system.

4.1.5 Level indicator shall be provided for measuring the quantity of water stored anytime. The indicator shall be graduated to read directly in m^3 of water.

4.1.6 Water reservoir/tank shall be cleaned at least once in two years or more frequently if necessary to prevent contamination and sedimentation.

4.1.7 It is advisable to provide adequate inflow into the reservoir/tank so that the protection can be re-established within a short period.

4.2 Pumps

4.2.1 *General Requirements*

4.2.1.1 Pumps shall be exclusively used for fire fighting purposes and shall be:

a) electric motor driven centrifugal pumps, or

b) compression ignition engine driven centrifugal pumps, or

c) vertical turbine submersible pumps,

in all the above cases, pumps shall be automatic in action and of approved type.

4.2.1.2 Pumps shall be direct coupled, except in the case of engine-driven vertical turbine pumps wherein gear drives shall be used.

Belt-driven pumps shall not be accepted.

4.2.1.3 Parts of pumps like impeller, shaft sleeve, wearing ring, etc, shall be of non-corrosive metal like brass or bronze.

4.2.1.4 The pressure and flow required to supply the most unfavourable and most favourable areas of operation shall be calculated. This calculated flow demand shall be taken on the intercept of the water supply curve with the most favourable demand curve.

4.2.1.5 In case of electrically driven pumps, it is recommended that a compression ignition engine driven stationary pump of similar capacity be installed as a standby and *vice-versa*. However, where the spray system consists of more than one pump or prime-movers of all pumps shall not be of same type.

Notwithstanding the above; if power to motorized fire pumps is obtained from two sources, one of which is a captive generating plant located in a block either 6 m away from all surrounding buildings or where this is not feasible, segregated from adjoining buildings in a manner indicated in **4.2.1.12** more than one pump may be of the electrically-driven type.

4.2.1.6 In case of jockey pumps in such systems to take care of minor leakages the capacity thereof shall not be less than 3 percent and normally not more than 10 percent of the installed pumping capacity.

4.2.1.7 Each pump shall be provided with a pressure gauge on the delivery side the pump and the non-return value and a plate giving the delivery head, capacity and the number of revolution/min.

4.2.1.8 Each fire service pump shall be provided with an independent suction pipe without any sluice or cut-off valves therein, unless the pump is situated below the level of the water supply in which case sluice or cut-off valves would be essential. Where the net positive suction head (NPSH) available at site is less than 0.5 m in excess of the actual value required at 150 percent of the duty point as per the manufacturer's curves or where the water supply has fibrous or equally objectionable matter in suspension or mud and/or sand liable to cause accumulation in the installation, suction pipe(s) shall be installed in jack well fed through a culvert from the main water supply. At the supply end of the culvert, a sluice or gate valve shall be provided.

4.2.1.9 The diameter of the suction pipe shall be such that the rate of flow of water through it does not exceed 90 m/min when the pump is delivering at its rated discharge. If, however, the pump is situated below the level of its water supply, the diameter of the suction pipe/ header shall be based upon a rate of flow of 120 m/min.

4.2.1.10 Centrifugal pumps shall be fixed below the level of the water supply. However, if the priming arrangements are such as to ensure that the suction pipe shall be automatically maintained full of water notwithstanding a serious leakage therefrom (the pump being automatically brought into action to replenish the priming tank should the latter be drawn upon at a greater rate than the rate at which it is fed from any other source), positive suction may not be insisted. In such cases, the capacity of the priming tank need not exceed 450 l and the diameter of the priming pipe need not exceed 50 mm.

NOTE — For the purpose of **4.2.1.8, 4.2.1.9** and **4.2.1.10** a pump shall be considered as having positive suction only if the quantity of water in the reservoir above the level of the top of the pump casing is equivalent to the requirements given in **5.2.2** and **6.2**.

4.2.1.11 If the pump is allowed to be installed above the level of its water supply in case of high velocity water spray systems, there shall be a foot valve and a 'priming' arrangement; the latter consisting of a tank (having a capacity at least three times that of the suction pipe-from-the pump to the foot valve) connected to the delivery side of the pump by a metal pipe having a diameter of 100 mm in the case of centrifugal pumps with a non-return valve therein of the same size. A dependable independent filling arrangement and a level indicator shall be provided for the priming tank. The provision of a vacuum gauge for the suction pipe is recommended.

4.2.1.12 Pumps shall not be installed in the open. The pump room shall be so located as to be both easily accessible and where any falling masonry and the like from other building occasioned by fire or other cause, cannot damage the pump room. Normally, pump rooms shall be located 6 m away from all surrounding buildings and overhead structures. Where this is not feasible, they may be attached to a building provided a fire resisting wall is constructed between the pump room and the attached building, the roof of the pump room is of R.C.C. construction at least 100 mm thick and access to the pump room is from the outside. The pump rooms shall normally have brick/concrete walls and non-combustible roof, with adequate lighting, ventilation and drainage arrangements.

NOTE — The pump room shall be located 30 m clear of equipment/vessels handling or storing flammable liquids/ solvents and/or gases.

4.2.2 *Electrically Driven Pumps*

4.2.2.1 The sub-station(s) supplying power to the fire pump(s) shall be of incombustible construction and shall be located at least 6 m away from all surrounding buildings. Where this is not feasible it may be attached to a building provided a fire resisting wall is constructed between the sub-station(s) and the attached buildings, the roof of the sub-station(s) is of R.C.C. construction at least 100 mm thick and access to the sub-station(s) is from the outside.

Transformer cubicles inside these sub-stations shall be separated from H.T./ L.T. cubicles and from each other by blank brick/stone/concrete walls of 355 mm thickness with wall openings, if any, therein being protected by single fire doors of some rating. Likewise, sub-station, and generator room shall be separated from each other. Outdoor transformers shall also be separated as above irrespective of their oil contents.

NOTE — The sub-station shall be located 30 m clear of equipment/vessels handling or storing flammable liquids/ solvents and/or gases.

4.2.2.2 Overhead feeders to sub-station(s) supplying power to the fire pump(s) are not permitted within a horizontal distance of:

a) 15 m of any process building/plant or tanks containing flammable liquids, or
b) 6 m of any other building or tanks containing non-flammable liquids or of storage in open.

In case the feed to such sub-station(s) is by means of underground cables, the cables shall not pass under any building or permanent structure.

4.2.2.3 Sufficient spare power shall always be available to drive pumping set(s) at all times throughout the year.

4.2.2.4 The electric supply to the pumping set(s) shall be entirely independent of all other equipment in the premises that is even when the power throughout the entire premises is switched off, the supply to the pump shall continue to be available uninterrupted. This can be achieved by taking the connection for the pump(s) from the incoming side of the main L.T. breaker. However, in cases where two or more transformers and/or sources of supply are connected to a common busbar or where there is provision of a bus coupler between the busbar sections, the connection may be taken through the busbars (*see* Fig. 1).

4.2.2.5 The fire pump circuit shall be protected at the origin by an automatic circuit breaker, so set as to permit the motor to be overloaded during an emergency to the maximum limit permissible by the manufacturers. Further, the under-voltage release/no volt coil of the circuit breaker shall be removed.

NOTE — Where cable lengths are long enough to warrant back-up protection, the same shall be necessary.

4.2.2.6 It is recommended that tell-tale lamps which would continuously glow when power is available to the fire pump(s) circuit be provided and fixed in a prominent position, both in the sub-station and in the pump room.

4.2.2.7 A direct feeder without any tapings, shall be laid from the sub-station to the pump house. The feeder shall be laid underground and shall not pass under any building or permanent structure.

4.2.2.8 Where there is more than one source of power for the operation of pumping set(s) every electrical circuit shall preferably be so designed as to ensure that when necessary, the set(s) continue to operate without the manual operation of an emergency switch.

4.2.2.9 The pumping set(s) shall be securely mounted on a robust bed plate, if of the horizontal type, and shall be free from vibration at all variations of load.

4.2.2.10 The rating and design of motors and switchgear shall conform to the relevant Indian

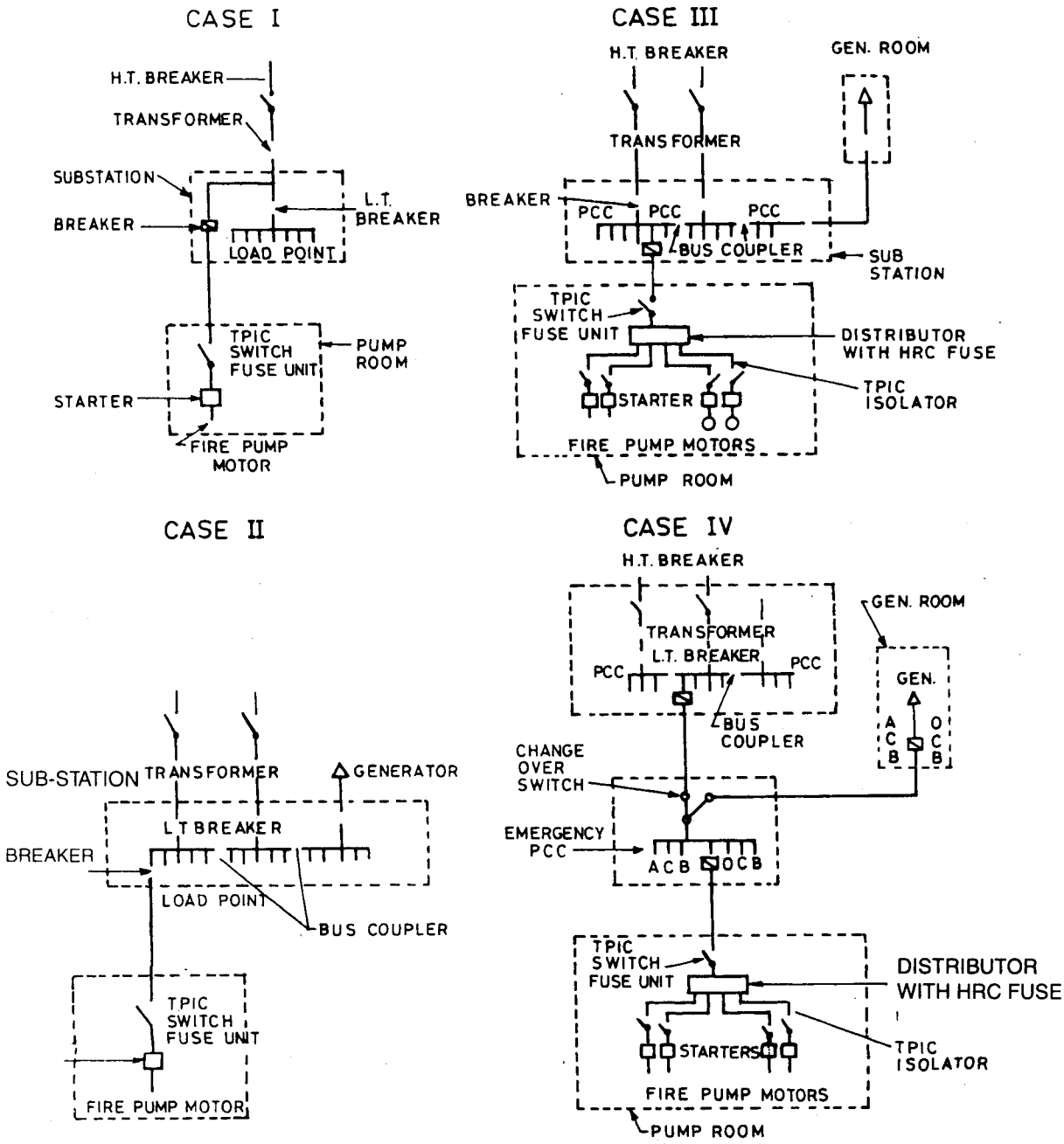

FIG.1 TYPICAL ARRANGEMENT FOR ELECTRIC SUPPLY TO FIRE PUMPS

Standards. The motor shall be of continuous rating type and its rating shall be equivalent to the horse power required to drive the pump at 150 percent of its rated discharge (*see* **4.2.1.7**).

4.2.2.11 The motor shall be of totally enclosed type or drip proof type, the latter having their air inlets and outlets protected with meshed wire panels to exclude rodents, reptiles and insects.

4.2.2.12 The motor(s) shall be wound for Class B insulation, preferably for Class E and the windings shall be vacuum impregnated with heat and moisture resisting varnish and preferably glass fibre insulated to withstand tropical conditions.

4.2.2.13 Motor(s) wound for high tension supplies shall have a suitable fixed warming resistance to maintain the motor windings in a dry condition at all times and particularly under monsoon conditions. The resistance shall be connected to the lighting or other equivalent circuit.

4.2.2.14 Heating apparatus shall also be provided, when necessary, for medium tension motor where they are located below ground level, in order to maintain the motor windings in a dry condition. Adequate

drainage arrangements shall also be provided in the pump house in such cases.

4.2.2.15 The incoming cable to the fire pump room shall terminate in an isolating switch fuse unit incorporating HRC fuses and where necessary provided with a distribution system.

4.2.2.16 The starting switch gear for the fire pumps shall be suitable for direct on line starting but other alternative arrangements are subject to prior approval. It shall also incorporate an ammeter with a clear indication of the motor full load current.

4.2.2.17 Cables for motors and switch gears shall be armoured or be enclosed in heavy gauge screwed steel conduit according to conditions.

4.2.2.18 It is recommended that equipment throughout be painted fire red conforming to shade No. 536 of IS 5 and suitably marked for identification.

4.2.2.19 Necessary spare parts including a set of fuses (in a glass fronted box) shall be kept in readiness at all times in the pump house.

4.2.2.20 The wiring in all installations shall be done in accordance with National Electrical Code.

4.2.3 *Compression Ignition Engine Driven Pumps*

4.2.3.1 *Pump room*

The pump room shall be artificially heated, if necessary, to maintain the temperature of the room above 10°C. Adequate ventilation shall be provided for the air required for aspiration and to limit the temperature rise in the room to 10°C above the ambient temperature when the engine is on full load.

4.2.3.2 *Engine*

The engine shall be:

a) of the compression ignition mechanical direct injection type, capable of being started without the use of wicks, cartridges, heater plugs or either, at an engine room temperature of 7°C and shall accept full load within 15 s from the receipt of the signal to start.

b) naturally aspirated, supercharged or turbo charged and either air or water cooled. In the case of charged air cooling by means of a belt-driven fan or of a belt driven auxiliary water pump there shall be multiple belts such that should half the belts break, the remaining belts would be capable of driving the fan or pump.

c) capable of operating continuously on full load at the site elevation for a period of 6 h.

d) provided with an adjustable governor to control the engine speed within 10 percent of its rated speed under any condition of load up to the full load rating. The governor shall be set to maintain rated pump speed at maximum pump load.

e) provided with an in-built techometer to indicate revolution per minute of the engine.

f) provided with a time totaliser (hour counter).

4.2.3.3 Any manual device fitted to the engine which could prevent the engine starting shall return automatically to the normal position.

4.2.3.4 Engines, after correction for altitude and ambient temperature, shall have bare engine horsepower rating equivalent to the higher of the following two valves :

a) 20 percent in excess of the maximum brake horse power required to drive the pump at its duty point, and

b) The brake horse power required to drive the pump at 150 percent of its rated discharge.

4.2.3.5 The coupling between the engine and the pump shall allow each unit to be removed without disturbing the other.

4.2.3.6 *Cooling system*

The following systems are acceptable :

a) Cooling by water from the discharge of fire pump (taken off prior to the pump discharge valve) direct into the engine cylinder jackets *via* a pressure reducing device to limit the applied pressure to a safe value as specified by the engine manufacturer. The outlet connection from this system shall terminate at least 150 mm above the engine water outlet pipe and be directed into an open tundish so that the discharge water is visible.

b) A heat exchanger, the raw water being supplied from the fire pump discharge (taken off prior to the pump discharge valve) *via* a pressure reducing device, if necessary, to limit the applied pressure to a safe value as specified by the engine manufacturer. The raw water outlet connection shall be so designed that the discharged water can be readily observed. The water in the closed circuit shall be circulated by means of an auxiliary pump driven from the engine and the capacity of the closed circuits shall not be less than that recommended by the engine manufacturer. If the auxiliary pump is belt driven there shall be multiple belts so that should half the belts break, the remaining belts shall be capable of driving the pump.

c) A frame or engine mounted air cooled radiator with a multiple belts driven fan from the engine. When half the belts are broken the

remaining belts shall be capable of driving the fan. The water in the closed circuit shall be circulated by means of an auxiliary pump driven by the engine and the capacity of the closed circuit shall be not less than that recommended by the engine manufacturer.

d) Direct air cooling of the engine by means of multiple belts driven fan. When half the belts are broken the remaining belts shall be capable of driving the fan.

NOTE — In case of systems described in (b), (c) and (d), a failure actuated audio-visual alarm shall be incorporated.

4.2.3.7 *Air filtration*

The air intake shall be fitted with the filter of adequate size to prevent foreign matter entering the engine.

4.2.3.8 *Exhaust system*

The exhaust shall be fitted with a suitable silencer and the total back pressure shall not exceed the engine maker's recommendation. When the exhaust system rises above the engine, means shall be provided to prevent any condensate flowing into the engine.

4.2.3.9 *Engine shut-down mechanism*

This shall be manually operated and return automatically to the starting position after use.

4.2.3.10 *Fuel system*

a) *Fuel* — The engine fuel oil shall be of quality and grade specified by engine makers. There shall be kept on hand at all times sufficient fuel to run the engine on full load for 3 h, in addition to that in the engine fuel tank.

b) *Fuel tank* — The fuel tank shall be of welded steel constructed as per relevant Indian Standard for mild steel drums. The tank shall be mounted above the engine fuel pump to provide a gravity feed unless otherwise recommended by the manufacturers. The tank shall be fitted with an indicator showing the level of fuel in the tank. The capacity of the tank shall be sufficient to allow the engine to run on full load for 1 h in case of high velocity water spray systems and 3 h in case of medium velocity water spray systems.

NOTE — Where there is more than one compression ignition engine driven pump set there shall be a separate fuel tank and fuel feed pipe for each engine.

c) *Fuel feed pipes* — Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. Pipe joints shall not be soldered and plastic tubing shall not be used.

d) *Auxiliary equipment* — The following shall be provided:

1) A sludge and sediment trap,
2) A fuel level gauge,
3) An inspection and cleaning hole,
4) A filter between the fuel tank and fuel pump mounted in an accessible position for cleaning, and
5) Means to enable the entire fuel system to be bled of air. Air relief cocks are not allowed; screwed plugs are permitted.

e) *Starting mechanism* — Provision shall be made for two separate methods of engine starting, namely:

1) Automatic starting by means of a battery powered electric starter motor incorporating the axial displacement type of pinion, having automatic repeat start facilities initiated by a fall in pressure in the water supply pipe to the spray installation. The battery capacity shall be adequate for ten consecutive starts without recharging with a cold engine under full compression.
2) Manual starting by:
   i) Crank handle, if engine size permits, or
   ii) Electric starter motor.

NOTE — The starter motor used for automatic starting may also be used for manual starting provided there are separate batteries for manual starting.

4.2.3.11 *Battery charging*

The means of charging the batteries shall be by a 2-rate trickle charger with manual selection of boost charge and the batteries shall be charged in position. Where separate batteries are provided for automatic and manual starting the charging equipment shall be capable of trickle charging both the batteries simultaneously. Equipment shall be provided to enable the state of charge of the batteries to be determined.

4.2.3.12 *Tools*

A standard kit of tools shall be provided with the engine and kept on hand at all times.

4.2.3.13 *Spare parts*

The following spare parts shall be supplied with the engine and kept on hand.

a) Two sets of fuel filters, elements and seals;
b) Two sets of lubricating oil filters, elements and seals;
c) Two sets of belts (where used);
d) One complete set of engine joints, gaskets and hoses;

e) Two injector nozzles;
f) One complete set of piston rings for each cylinder; and
g) One inlet valve and one exhaust valve.

4.2.3.14 *Engine exercizing*

The test shall be for a period of at least 5 min each day. Where closed circuit cooling systems are used the water level in the primary system shall be checked at the time of carrying out each test and, if necessary, water shall be added during the course of the test procedure.

4.2.3.15 A written declaration shall be given that the following conditions will be strictly complied with:

a) To test the engine at least once a week,
b) To maintain the temperature of the engine room at not less than 4.5°C at all times,
c) To maintain the minimum quantity of fuel oil required as desired in these clauses,
d) To use a good grade of fuel oil equivalent in quality to that specified by the engine maker, and
e) To keep on hand the spare parts required as specified in **4.2.3.13**.

4.3 Detection System

Detection systems are designed to detect one or more of three characteristics of a fire that is smoke, heat and radiation. No one type of detector is most suitable for all applications and final choice will depend on individual circumstances.

In any automatic fire detection system, a detector has to discriminate between a fire and the normal environmental conditions. The overall objective of the system is intended not only to enable a fire to be detected at an early stage of its occurrence but also to extinguish the fire without extensive property damage.

In case of water spray systems, detection systems are required for activating the deluge system for the following applications:

a) General area protection (indoors),
b) Horizontal and vertical vessels (outdoors),
c) Spherical vessels (outdoors),
d) Transformers (outdoors and indoors), and
e) Spot protection such as oil tanks, turbo-alternator sets, pipe lines, etc, (outdoors and indoors).

For most of the above protections, sprinklers are found in extensive application in view of their reliability. Sprinklers are not fast enough for certain applications, for example, general areas like open-sided bottling plants for LPG and the like, open-sided chemical plants handling low flashing solvents, etc, where a quick detection is required to avoid an inferno or a possible bleve. For such specialized applications, suitable types of detectors are being identified. At present, sprinkler is being accepted as a detector for all applications in case of water spray systems. The present Code covers direction by sprinker only. However, other type of detections, for example, in cable galleries/conveyor by LHS cables, in warehouses by smoke/R.O.R. detectors, etc, will be acceptable provided full details of such systems with design philosophy are available.

The design of detection system by sprinklers varies from risk to risk in case of water spray systems. Hence the different methods have been separately covered under each section. However, there are certain requirements which are common to all types of protection and only such requirements are given.

4.3.1 *General Requirements*

4.3.1.1 The sprinkler piping shall *not* be less than 25 mm diameter anywhere. However, where air/ nitrogen/water is used in the detection network, and the bursting of quartzoid bulb trigger deluge valve operation, resulting in high velocity or medium velocity water spray actuation, the detection net work piping shall be of 6/8 mm thickness minimum.

4.3.1.2 The total pipeline volume shall not be less than 10 litre.

4.3.1.3 The pressure in the detection system shall, in no case, exceed 3.5 bars.

4.3.1.4 The detection piping shall slope to drain at least 1 in 250 with drain valves provided at the lowest point.

4.3.1.5 For pneumatic, separate air compressor shall be provided for the detection system. The air compressor shall be installed in the fire pump room. Where it is not possible, the air compressor room shall be separated from the occupancies adjoining therewith as per **4.2.1.12**.

4.3.1.6 Wherever possible in case of pneumatic systems stand-by air compressor may be installed or supplies from process and utility compressors may be connected as an alternate supply to the detection system.

4.3.1.7 As far as possible, the detection piping shall be run alongside the underground spray mains but run independently of other pipes, either underground or aboveground. The piping shall be suitably protected against impact damage in the case of the latter.

4.3.1.8 The detection piping shall not traver underneath or through any working/storage blocks or tank farms/

materials stored in open.

4.3.1.9 The temperature rating of the detector sprinkler shall be 68°C above the highest ambient temperature at the site of installation.

4.3.1.10 The detection piping and equipment installed in corrosive areas shall be applied with protective coatings.

4.3.1.11 The detection piping and equipment shall be supported independently as far as possible.

4.3.1.12 The detection piping/equipment shall be laid away from not sources such as heat exchangers, furnaces, ovens, etc, in order to avoid possible false alarms.

4.3.1.13 Sprinkler heads shall be provided with guards in areas where they are susceptible to mechanical damage and care shall be taken to see that the guards do not interfere with the spray pattern in the vicinity.

4.3.1.14 The detection system shall be designed to cause actuation of the deluge valve within 20 s under expected exposure conditions.

4.3.1.15 It is recommended to provide baffle plates for detectors where situation warrants.

4.4.1 *Piping*

4.4.1.1 The pipe used in the water spray system (from pump house up to the deluge valve) shall be laid underground or in masonry culverts with removable covers of incombustible construction and shall be of any one of the following types:

a) Cast iron double flanged Class A pipes conforming to the following standards:

   1) Horizontally cast iron pipes : IS 7181
   2) Vertically cast iron pipes : IS 1537
   3) Centrifugal cast (spun) iron pipes : IS 1536

   NOTE — In case of vertically cast pipes, where the nominal diameter of the pipes exceeds 300 mm or where the pump delivery pressure exceeds 7 kg/cm^2, Class B pipes would be necessary.

b) Centrifugal cast (spun) iron Class A pipes with tyton joints : IS 1536.

c) Wrought or mild steel pipes (galvanized or ungalvanized) or medium grade conforming to IS 1239 and IS 1978 or steel pipes conforming to IS 3589 having welded joints and coated and wrapped as per IS 10221.

d) Welded and seamless steel pipe.

e) Electric resistance welded steel pipe.

f) Black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe for fire protection use.

g) Wrought steel pipe.

NOTE — At least 10 percent of all the welded joints shall be radiographically tested and half of the joints radiographed shall be field joints.

4.4.1.2 Underground pipes shall be laid not less than 1 m below ground level. Where soil conditions are unsatisfactory, masonry or equivalent supports shall be provided at regular intervals.

NOTE — In case of poor soil conditions, it may be necessary to provide continuous masonry or equivalent supports.

4.4.1.3 Pipes may be laid above ground and shall be of medium grade wrought or mild steel (galvanized or ungalvanized) conforming to IS 1239 or IS 3589 or as listed in items (d), (e), (f) and (g) of **4.4.1.1** with welded, threaded or flanged joints, shall be adequately supported at regular intervals not exceeding 3.5 m and shall be run at least 6 m away from the face of the buildings or battery limit or open storage areas in case of high velocity water spray systems and 15 m in case of medium velocity water spray systems.

4.4.1.4 Pipes shall not be laid under buildings or plant areas or storages areas. As far as possible, pipes shall not be laid under large open storage, railroads and roads carrying heavy traffic.

4.4.1.5 Pipes shall not traverse ground which is not under the control of the owner of the installation. Pipe shall also not pass through public roadways.

4.4.1.6 The underground piping network shall be capable of withstanding for 2 h a pressure equivalent to 150 percent of the maximum working pressure.

4.4.1.7 All bolt holes in flanges shall be drilled.

4.4.1.8 Flanges shall be faced and have jointing of rubber insertions or asbestos compound.

4.4.1.9 For the system piping network above deluge valve, piping shall be galvanized internally and externally.

NOTE — However, wrought steel or mild steel pipes of heavy grade conforming to IS 1239 may also be used with proper anti-corrosive coating or treatment.

4.4.1.10 Welded joints shall not be permitted for pipes of less than 50 mm diameter.

4.4.2 *Fittings*

4.4.2.1 Fittings installed underground shall be of cast iron heavy grade conforming to IS 1538 whereas those installed above ground shall be of medium grade wrought steel or mild steel conforming to IS 1239 (Part 2) or malleable iron fittings conforming to IS 1879.

4.4.2.2 All fittings shall be able to withstand at least a pressure 150 percent of the working pressure.

4.4.2.3 For the system piping network above deluge valve, galvanized fittings shall be used.

NOTE — However, wrought or mild steel fittings of heavy grade conforming to IS 1239 (Part 2) may also be used with proper anti-corrosive coating or treatment.

4.4.2.4 Welded fittings in accordance with the laid down welding procedure are permitted. Welded parts shall be galvanized or suitably coated after welding as per the requirement of the areas to be protected by the system (that is chemical and electrolytic corrosion).

4.5 Deluge Valves

A deluge system is a fixed fire protection system which totally floods an area with pressurized water through a system of piping with open nozzles and/or sprinklers. The system piping is empty until the controlling valve is activated by a pneumatic or other types of release systems. Such controlling valves which are quick opening in nature are called deluge valves. The deluge valve assembly consist mainly of the following:

a) In line strainer,
b) Isolation valve,
c) Deluge valve,
d) Actuator/pilot assembly,
e) Drain valve,
f) Pressure gauges (above and below the deluge valve), and
g) Alarm assembly (consisting of gong or sounder).

4.5.1 *Principle of Operation*

The deluge valve has an inlet, outlet and priming chamber. The inlet and outlet are separated from the priming chamber by the valve chamber and diaphragm. In the 'SET' position, pressure is applied to the priming chamber through a restricted prime line. The pressure is trapped in the priming chamber and holds the clapper on the seat due to the differential design. In the set position, the clapper separates the inlet from the outlet keeping the system piping dry. When the pressure is released from priming chamber faster than it is supplied through the restricted priming line, the clapper moves and allows the inlet water supply to flow through the outlet into the system and associated alarm device. The mode of actuation of deluge valve can be pneumatic or hydraulic type or a combination of both.

4.5.2 *Requirements of Installation*

a) Deluge valve shall be installed outside but adjacent to the protected area as close to the risk as possible but at not less than 6 m from the plant and/or equipment to be protected.
b) Masonry enclosures shall be provided around the deluge valve in the form of barrier walls in such a way that the valve is not exposed to any impact due to flying bodies or projectiles from the plant and/or equipment in the vicinity and also for weather protection.
c) Isolating valves shall be provided below the deluge valves to enable servicing thereof and cleaning strainers at regular intervals.
d) Isolating valves shall be provided above the deluge valve in addition, for testing purposes.
e) The isolating valves shall be strapped and locked in 'Open' position by leather straps or nylon chains and pad-locks under normal operating condition.
f) Emergency manual override facility shall be provided for actuating the deluge valve.
g) It is permissible to provide a manually operated bypass line with an isolating valve for emergency requirements. Such valves shall always be kept locked in closed position.
h) The load on the deluge valve shall not exceed the limits mentioned below:

Valve Size mm	*Litre per minute*
150 mm	13 500
100 mm	5 000
80 mm	1 150

j) Indicators shall be provided to show the open and closed positions.
k) Facility shall be provided to prime the space above the deluge valve seat with water.
m) It must be ensured that there is no possibility of water leaking back into the instrument air supply in the event of diaphragm failure.
n) A suitable, durable, robust and clearly visible instruction plate shall be permanently secured to each assembly and shall detail clearly and concisely the following procedures:
   1) Start up (or operation),
   2) Test,
   3) Shut down, and
   4) Drain.

4.6 Drainage

Adequate provisions shall be made to promptly and effectively dispose of all liquids from the fire area during operation of all systems in the fire area. Such provisions shall be adequate for:

a) Water discharged from fixed fire protection systems at maximum flow conditions,
b) Water likely to be discharged by hose streams,
c) Surface water, and

d) Cooling water normally discharged to the systems.

There are four methods generally adopted for disposal and/or containment that is grading, diking, trenching, underground or enclosed drain systems.

The method used in drainage shall be governed by:

a) Extent of the hazard,
b) Clear space available, and
c) Protection required.

4.6.1 Where the hazard is low, the clear space is adequate and the degree of protection required is not great, grading is acceptable. Where these conditions are not present, consideration shall be given to dikes, trenches or underground or enclosed drains.

4.6.2 Where grading is employed, a slope of not less than 1 percent shall be necessary. Concrete surfacing is mostly desirable, however, other hard surfacing are acceptable.

4.6.3 Where diking is employed, the drainage arrangements thereof shall conform to *Indian Petroleum Rules* in all respects.

4.6.4 Where trenching, underground or enclosed drains are employed reference shall be made to the appropriate authorities with full particulars for approval.

5 HIGH VELOCITY WATER SPRAY SYSTEMS

5.1 High velocity water spray systems are installed to extinguish fires involving liquids with flash points of 65°C or higher. Three principles of extinguishment are employed in the system that is emulsification, cooling and smothering. The result of applying these principles is to extinguish the fire within a few seconds.

This clause provides guidelines for the protection of the following:

a) Transformers, oil filled equipments of power stations,
b) Turbo-alternators and other,
c) Oil fired boiler rooms, oil quenching tanks, and
d) Cable vaults.

5.2 Transformer Protection

5.2.1 *General*

5.2.1.1 Transformer protection shall contemplate on essentially complete impingement on all exterior surfaces except the underside which may be protected by horizontal projection.

5.2.1.2 Transformer present particular design problems for water spray protection, primarily due to their irregular shape and necessary clearances to be provided for the high voltage equipment. Generally speaking, there is much more interference with the water flow on the sides of the transformer than at their top. Due to this reason the protection usually involves a large number of small capacity projectors than a few bigger ones. Often it will be necessary to put more water on the transformer than required to achieve complete impingement and total envelopment.

5.2.1.3 Hence it is necessary to cross-check the following informations from the detailed drawings to check the design of spray system of a transformer :

a) Length of the transformer,
b) Width of the transformer,
c) Height of the transformer,
d) Location and height of bushings,
e) Size and location of oil conservator tank,
f) Location of switch boxes, tap changing gears, explosion vents, piping/flanges and other equipment that obstruct and interfere with water distribution,
g) Specification such as KV A rating, voltage rating, oil quantity, etc,
h) Details showing the direction of incoming and outgoing cabling and ducting,
j) Details of flooring on which the transformer is installed and nature of floor around the transformer, such as, concrete, asphalt, pebble filled, etc,
k) Elevation of transformer above the grade,
m) Size and location office barrier walls,
n) Sitting of radiators and cooler banks in relation to the transformer and the surrounding ground level,
p) Protection and detection piping in different colours, and
q) Projector characteristics showing the '*K*' factor, cone angle, discharge in LPM, and effective reach.

5.2.1.4 The projection from the surfaces like ribbings, tap changers, cable boxes, etc, would 'roof off' the downward flow of water and hence 'run down' cannot be automatically considered. Such 'roofed off' areas will require specific spray coverage with additional projector.

5.2.1.5 *Electrical clearance*

All system components shall be so located as to maintain minimum clearances from live parts as shown in Table 1.

'Clearance' is the air distance between water spray equipment including piping nozzles and detectors and

uninsulated live electrical components at other than ground potential. The minimum clearances specified in Table 1 are under normal conditions. During the operation of water spray system, they are intended for use as safe. The values stated are as per requirements of National Electrical Code of the Bureau of Indian Standards.

Table 1 Minimum Electrical Clearances

(*Clause* 5.2.1.5)

Sl No.	Maximum R.M.S. Value of Rated Operation Voltage	Minimum Distance of Installation Subject to Over Voltages	Minimum Distance of Installations Protected Against Over Voltages Connected to Cables
	kV	mm	mm
(1)	(2)	(3)	(4)
i)	10	150	150
ii)	20	215	160
iii)	30	325	270
iv)	45	520	380
v)	60	700	520
vi)	110	1 100	950
vii)	150	1 550	1 350
viii)	220	2 200	1 850
ix)	400	3 500	3 000

NOTE — If the clearance around the transformer (outdoor and indoor) is likely to be affected by the spray pipe network, specific reference shall be made.

5.2.1.6 Pipeline strainers shall be of approved type for use in water supply connections. Strainers must be capable of removing from the water, all solids of sufficient size to obstruct the spray nozzles (normally 3.2 mm perforations are suitable). In addition, the strainer must be capable of continuous operation without serious increase in head loss, for a period estimated to be ample when considering the type of protection provided, the condition of the water and similar local circumstances. In addition, pipeline strainers must incorporate a flush out connection. Individual strainers for spray nozzles where required must be capable of removing from the water all solids of sufficient size to obstruct the spray nozzle they serve.

5.2.2 *Water Supplies*

The effective exclusive capacity of the reservoir/tank (above the level of the foot valve seat in case of negative suction of permitted and above the level of the top of the pump casing in case of positive suction) shall not be less than 40 min aggregate pumping capacity for the spray system.

5.2.3 *General Layout and Design*

5.2.3.1 Transformers shall be protected using rings of nozzles there around with the top of the transformer and subsequently rings for every 3 m from top to bottom thereof and beneath each continuous obstruction. The rings shall not be located at more than 1 m of the transformer.

5.2.3.2 Projectors shall be employed to spray water horizontally at the bottom if the transformer is at more than 300 mm above ground level.

5.2.3.3 In case of transformers surrounded by concrete or asphalted surfaces, projectors must be employed in such a way as to wash off flammable liquids away from transformers.

5.2.3.4 *Projectors*

a) The projector shall not be less than 6 mm orifice in size.

b) Projectors protecting the top shall be aimed at an angle so that all of the water impinges upon the transformer, the spray pattern targeting either the top of the transformer or partly the top and partly the sides.

c) Projectors protecting the vertical sides and the bottom of the transformer shall point directly on the surfaces to be protected.

d) Projectors protecting irregular areas shall be located for the best coverage.

e) Projectors protecting the space between transformers and radiators and/or space between radiators shall be so located as to spray directly into the open space.

f) Projectors shall cover the oil pipe joints and flanges, if any.

5.2.3.5 *Fire barrier walls*

a) Fire barrier walls shall be constructed between the transformers/equipment and these walls shall be of either 355 mm thick brick or 200 mm thick RCC and carried at least 600 mm above the highest point of equipment to be protected.

b) Fire barrier wall shall be constructed between the transformers/equipment which are not spaced at distances mentioned below:

Oil Capacity of Transformers	*Individual Clear Separating Distance*
l	m
Up to 5 000	6.0
Between 5 001 and 10 000	8.0
Between 10 001 and 20 000	10.0
Between 20 001 and 30 000	12.5
Over 30 000	15.0

c) In the absence of walls as stated in **5.2.3.5** (a) or clear separating distances as stated

in **5.2.3.5(b)**, the pressure and flow demand shall be based on the aggregate requirements for all such transformers/equipment and pipe size, pumping capacity and water requirements shall accordingly be designed.

5.2.3.6 *System design*

a) *Density of discharge* — Water shall be applied at a rate of not less than 10.2 l/min/m^2 of the surface area of the entire transformer including the bottom surface, radiators, conservators, etc.

b) *Distribution of projectors and the layout of piping*

1) Projectors on the rings shall be located at not less than 500 mm and not more than 800 mm from the transformers/ equipment surface.

2) The horizontal and vertical distances between the projectors shall be maintained in such a way that their spray patterns intersect on the surface of the transformer/equipment.

3) Obstructed or 'roofed off' portions (*see* **5.2.1.4**) of the transformers shall be protected by separate projectors. For this purpose, it will be permissible to extend pipes from the nearest ring by means of a nipple. The terminal pipes extended from the ring mains shall need separate supports if they are 600 mm or longer.

4) Where radiators or cooler banks are located at more than 300 mm from the surrounding ground level, undersides shall be protected by projectors pointing upwards.

5) Where radiator/cooler bank are spaced more than 300 mm apart and where the transformer is separated at a distance of more than 300 mm from the radiator/ cooler bank, projectors shall be so arranged to spray into the space. Projector angles shall be so selected that the cone diameters at the entrance of space is equal to or slightly larger than the space.

6) For unobstructed vertical surface, the maximum vertical distance between projectors shall be 3 m. However, for obstructed surface the distance shall be governed by the nature of obstruction.

7) The system shall be hydraulically so designed that the pressure at the hydraulically most remote projectors in the network is not less than 3.5 bars in case of an outdoor transformer and 2.8 bars in case of an indoor transformer. However, the maximum pressure in any projector within a network shall not exceed 5 bars. The velocity in the feed pipes shall not exceed 10 m/s.

5.2.4 *Detection System for Transformers*

Automatic detection equipment shall be so located and adjusted as to operate reliably. The location of detectors shall be based on several factors such as nature of hazard, air velocity, temperature variations, configuration of the hazard, indoor or outdoor, open or closed structures and other variables. For transformers, the detector sprinklers shall be as close to the shell as possible at all places subject to electrical clearance.

5.2.4.1 *Outdoor transformers*

a) There shall be a ring of detectors around the top of the transformer and a second ring around the base. Pipe work is likely to be affected by stray magnetic fields that can produce inductive heating if there is a continuous metallic ring. Hence continuous ring mains shall be avoided.

b) The detectors shall be spaced at a maximum of 2.5 m intervals.

c) The detectors shall be close to the transformer as possible and shall in no case be farther than 300 mm therefrom.

d) Additional detectors shall be required for specific known hazard points such as tap changers, cable boxes, vents, oil piping, etc.

e) Coolers and radiator banks associated with the transformer shall be provided with detectors at two levels in a manner as specified in **5.2.4.1**(a).

f) The flanges of oil pipes shall be within 300 mm from detectors.

g) The conservator tanks shall be provided with detectors at 2.5 m spacing. It is sufficient to install detectors under the conservator tanks.

h) Piping shall be individually supported as far as possible. Transformer ribbings may be used to support the piping. In no case, shall the piping be supported on the body of the transformer.

j) Terminal pipes (other than those for projectors protecting 'roofed off' portions) longer than 300 mm shall be supported separately.

5.2.4.2 *Indoor transformers*

a) Where the transformer cubicle is less than 6 m in height, the detectors shall be positioned in accordance with IS 2189, that is, at a maximum spacing of 4 m with an area coverage of not more than 12 m^2 over the risk.

b) Where the transformer cubicle is more than 6 m in height, the detectors shall be positioned as close to the transformer as possible to the top of the transformer.

c) Where the transformer cubicle is open fronted, the same shall be treated as an outdoor transformer with detectors as per **5.2.4.1**.

5.3 Miscellaneous Protection

High velocity water spray systems are also provided for the protection of following areas in power stations:

a) Burners, air preheating systems, lubricating oil systems,

b) Hydrogen cooling and seal oil systems,

c) Inside turbo-alternator sets, and

d) Clean and dirty oil tanks, paraffin tanks.

The design details shall be governed by various provisions given in **5.2**.

6 MEDIUM VELOCITY WATER SPRAY SYSTEM

6.1 Medium velocity water spray systems are installed to control the burning and to provide cooling and/or exposure protection to such risks where extinguishment is always not possible or even desirable, for example, fires involving flammable fluids having flash points below 65°C. These 60°C systems are also used sometimes for power station applications in coal conveyors, cable galleries, etc.

6.1.1 This clause provides guidelines for the protection of the following areas by medium velocity water spray system:

a) General area protection plants where flammable solvents are stored and/or used;

b) Horizontal storage vessels (for example, LPG bullets, etc);

c) Vertical storage vessels (for example, benzene, xylene, toluene tankage);

d) Spherical storage vessels (for example, LPG bullets, spheres, etc); and

e) Spot protection (protection of selective areas/ equipments).

6.2 Water Supplies

The effective exclusive capacity of the reservoir/tank above the level of the top of the pump casing shall be as follows:

a) 90 min of the installed pumping capacity if the aggregate hold-up of flammable fluid/ solvent in vessels/tanks at one location is less than 200 m.

b) 150 min of the installed pumping capacity if the aggregate hold-up of flammable fluid/ solvent in the vessels/tanks at one location is more than 200 m.

For the purpose of the above, all storage vessels within 50 m of each other shall be considered as one location.

6.3 Pumping Capacity

To determine the actual pumping capacity required for the system, individual demands of various detached blocks within the risk shall be determined based on the design details given in the following sections. The pumping capacity required shall be equivalent to the highest of the demands thus calculated.

6.4 General Area Protection

6.4.1 *Definition*

A process plant where flammable liquids are contained in vessels and/or pipes forming a large or small complex of the plant either in a room or outdoors or under a roof with open sides would be classified as a 'General area'. A plant wherein more than 1 000 litre of flammable liquids/solvents are stored in small containers, would also be classified as a 'General area'.

6.4.2 *General Information*

The density of water application shall depend upon the type of flammable liquids handled in the plants and also upon the object of protection and site conditions. The examples include:

a) Controlled burning of spilt liquid,

b) Exposure protection of plant and its structure,

c) Ceiling height of the risk,

d) Area of the fire involved, and

e) Type of containers holding the flammable liquid.

6.4.3 *General Requirements*

6.4.3.1 Sprayers installed at ceiling level shall provide general area protection for spill fires and of uninsulated structural steel columns/trusses up to 3 m from the ceiling sprayers.

6.4.3.2 If the ceilings or roofs are of either A.C. sheet or G.I. sheet and the like or combustible materials, additional open type sprinklers shall be provided exclusively to protect them with a degree of wetting.

6.4.3.3 Where the height of ceiling/roof of the plant exceeds 13 m from the flooring below, conventional open type sprinklers shall be employed instead of sprayers.

6.4.3.4 Vessels, drums, pumps, valves, manifolds and flammable liquid pipes inside the plant shall need to be protected by sprayers installed at a lower level.

6.4.3.5 If there are obstructions extending below the ceiling sprayers and they are more than 1 m in width, underneath of such obstructions shall be protected by local sprayers.

6.4.3.6 Structural steel work supporting access platforms, catwalks, ladders, etc, may be protected by separate sprayers.

6.4.3.7 As far as possible, the sprayers installed at lower levels (*see* **6.4.3.4**, **6.4.3.5** and **6.4.3.6**) shall be provided with baffle plates.

6.4.3.8 It may be necessary to cross-check the following details from full detailed drawings before designing the system:

a) Plan and sectional views of the risk floor wise showing the dimensions of the block, equipment lay-out, nature of floors/roof, minimum and maximum ceiling height, etc.
b) Columns, beams and trusses of the supporting structure.
c) The working details of sprayers, sprinklers, detectors, piping, their spacing, zone division, etc.
d) Location of deluge valves, piping, detector piping, their sizes, etc.
e) Typical mounting arrangements of sprayers, sprinklers, detectors, etc.
f) Separate drawing showing the various nodes only, for hydraulic calculation.
g) Characteristic curves of sprayers and sprinklers showing their pattern, orifice size, *K* factor, spray angle, discharge in l/min, etc.
h) Full details of the liquid handled indicating their quality, chemical properties, etc.
j) Upto-date block plan showing clearly the distances between various blocks, underground tank, mains and their size, detector mains, deluge valves, pump house, water reservoir, etc.
k) A detailed note on the protection scheme elucidating the design philosophy.

6.4.4 *Design Density*

The density of water application depends upon the flash point of the liquids handled and also the ceiling height of the risk. The correct rate of density shall be derived from Fig. 2.

NOTE — The ceiling height to be used in determining the density shall be the minimum distance between the floor level of the plant and the ceiling.

6.4.4.1 The density obtained as above shall be loaded by the fire area factor $\{[b(a+b)]/900\} + 0.33$ where 'a' is the longer side and 'b' is the shorter side of the fire area measured in metres. If the risk is circular in shape 'a' may be treated equal to 'b' and same if it is square. If it is rectangular and 'a' is more than '$3b$', it shall be taken as equal to '$3b$' irrespective of the dimensions.

NOTES

1 If the factor calculated is less than 1, the same may be taken as 1.

2 After loading the basic density with the fire area factor, if the density works out to be greater than that of close control needs, the same may be taken as that of the latter.

6.4.5 *Layout of Protection Network*

6.4.5.1 The discharge cone angles of the sprayers shall be selected from Fig. 3 which relates height of the risk with the required angle. Any angle within the shaded area is deemed acceptable.

NOTES

1 If the height of the risk exceeds 13 m, conventional sprinklers (open type) shall be installed.

2 Where heights of less than a metre are encountered, sprayers with discharge cone angles of 1 000°C shall only be installed.

6.4.5.2 There shall be at least one sprayer to each 9 m^2 area of the floor of the risk.

6.4.5.3 The distance adjoining sprayers shall not exceed 3 m anywhere.

6.4.5.4 The distance between the last sprayer and the external wall or limits of the area shall not exceed 1.5 m anywhere.

6.4.5.5 The sprayer piping shall be installed along the slope of the roof (in case of sloping roof) but the sprayers shall discharge water on the risk in a vertical pattern.

6.4.5.6 In case of grating floors or perforated floors, the general area protection as per Fig. 3 shall be provided under the lowest floor. Under the other floors the sprayers shall be provided to discharge on to the floor below equipments, structural steel, etc, at a rate of not less than 10.2 l/min/m^2.

NOTE — In case of R.C.C. floors, each floor shall be protected at the same density as determined in **6.4.4.1**.

6.4.5.7 *Equipment protection*

a) If the tops of the vessels are more than 5 m below the ceiling and/or platform, individual local protection shall be provided by sprayers at a density of not less than 10.2 l/min/m^2 to cover top and sides thereof.

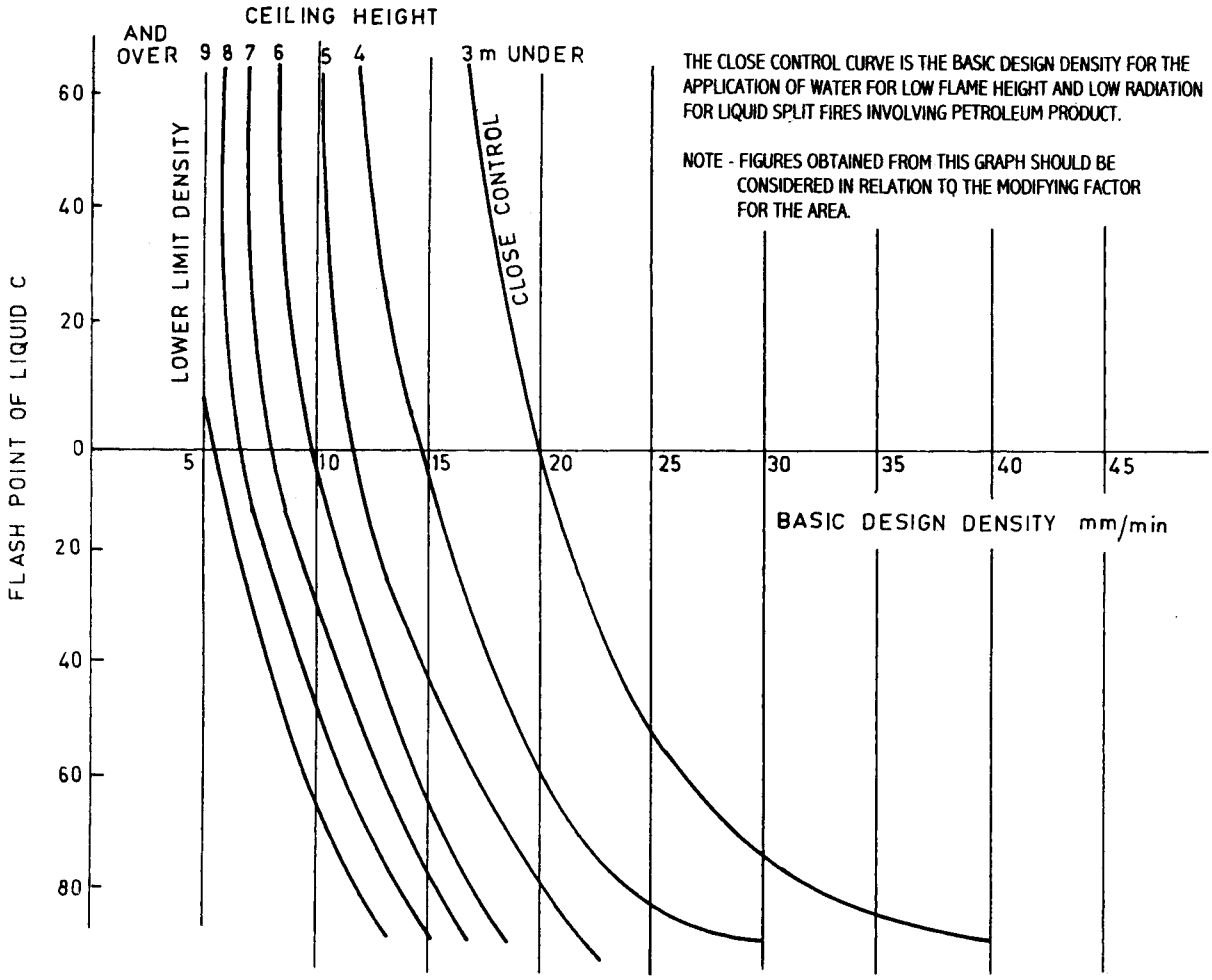

FIG. 2 DESIGN DENSITY

b) Any obstructions below the ceiling sprayers if exceeding 1 m in width, shall be protected underneath by individual sprayers at the same density.

c) Similarly undersurface of vessels and equipment if raised 300 mm above the floor level shall be wetted by individual sprayers at the same density.

d) Pumps, valves and manifolds, etc, shall be totally wetted by individual sprayers at the same density.

6.4.6 *Structural Protection*

6.4.6.1 In all cases, the load bearing structural steelwork for the plant and the roof, at levels exceeding 3 m below the sprayer at ceiling level shall be wetted at a rate of not less than 10.2 l/min/m^2 over the surface area of the structural members.

NOTE — Un-interrupted 'Run down' up to 4.5 m below the level of sprayers is permissible.

6.4.6.2 Columns and beams shall be wetted on each side of the steel sections by staggering the sprayers.

6.4.6.3 Any other structural steel work (whether load bearing or not) which can be subjected to flame-impingment shall also be wetted at not less than 10.2 l/min/m^2.

6.4.6.4 *Roof protection*

a) To provide wetting for the roof, conventional open type sprinklers shall be installed in such a way that there is at least one sprinkler for every 9 m^2 area of the roof.

b) Layout of such sprinklers shall be in accordance with those for sprayers as given in **6.4.5.2** and **6.4.5.3**.

c) Sprinklers shall be installed normal to the roof and piping shall be laid along the roof (in case of sloping roof).

6.4.7 *Piping and Supports*

6.4.7.1 Sprayer and sprinkler pipes shall be supported from the building structure which itself shall be capable of supporting the water filled pipe work and shall not impair the performance of sprayers/sprinklers, under fire condition.

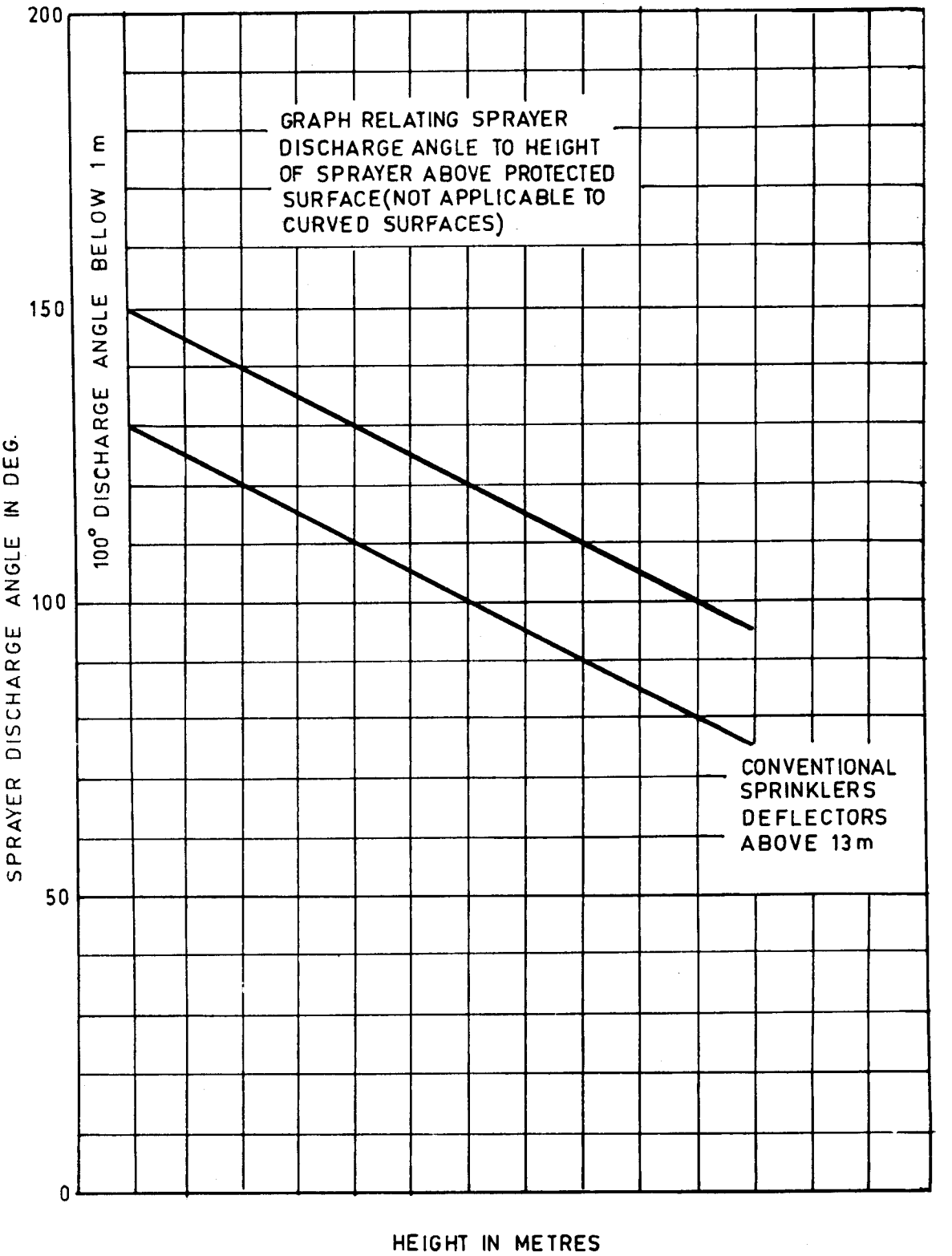

FIG. 3 LAYOUT OF PROTECTION NETWORK

6.4.7.2 Pipe-work shall not be used to support any other loads except where primary support is designed for the suspension of piped services.

6.4.7.3 Distribution pipes shall not be supported from ceiling or cladding or from any other associated suspension systems.

6.4.7.4 Pipes below obstructions, such as, duct work shall be either supported from the building structure or from the steel members supporting such obstructions. Such members shall be capable of supporting the weight of water filled pipes too.

6.4.7.5 Hangers shall not be welded or fastened directly to the pipe work.

6.4.7.6 The supports on which the pipe work rests shall be secured firmly in position.

6.4.7.7 The thickness of all parts of pipe supports shall not be less than 3 mm.

6.4.7.8 Wherever possible, pipes shall be supported from non-combustible building elements.

6.4.7.9 Pipe work in corrosive areas shall be suitably protected against corrosion.

6.4.7.10 The distance between the pipe supports measured along the line of connected pipes (whether the pipes run vertically, horizontally or at angles) shall not be less than the following:

Diameter	*Spacing*
	m
Up to 65 mm	4
Between 65 mm and 100 mm	6
Between 100 mm and 250 mm	6.5

6.4.7.11 *Distribution pipes*

a) The first support on a nominally horizontal distribution pipe shall not be at more than 2 m from the main distribution pipe.

b) The last support on a nominally horizontal distribution pipe shall not be more than 450 mm from the end.

c) Drop or rise pipes shall be secured to the building structure either directly at the adjacent nominally horizontal part of the pipe within 300 mm of the drop or rise.

6.4.7.12 *Range pipes*

a) At least one support shall be provided for:

1) Each pipe run connecting adjacent sprayer/sprinkler, and

2) The pipe run connecting the distribution pipe and the first sprayer/sprinkler on the range pipe.

b) Pipe supports shall not be closer than 150 mm to any sprayer/sprinkler axial central line.

c) The first support on a range pipe shall not be more than 2 m from the distribution pipe.

d) The last support on a range pipe shall not be more than 1.5 m from:

1) The range pipe end, or

2) Where there is a horizontal arm pipe of 450 mm or longer, the arm pipe end, or

3) Where there is a drop or rise exceeding 600 mm, the drop or rise pipe end.

6.4.7.13 Welded joints shall not be permitted for pipes and fittings of less than 50 mm diameter.

6.4.7.14 Outgoing mains from the deluge valve to the system shall be supported at every 3.5 m of its run.

6.4.8 *Hydraulics*

For the protection of large areas, it is permissible to divide the risk into several zones of not less than 6 m in width and all zones in plan view of the risk falling within 6 m from any point within a zone shall operate simultaneously.

Each zone shall be controlled by an individual deluge valve and flow through the valves shall not be more than the following:

Deluge Valve Size	*Discharge Flow*
mm	l/min
150	13 500
100	5 000
80	1 150

Each zone shall be so designed that the pressure at the hydraulically most unfavourable sprayer/sprinkler is not less than 1.4 bars and that at the most favourable sprayer/sprinkler is not more than 3.5 bars and that the velocity in distribution pipes shall not exceed 5 m/s.

Orifice plates, if required, shall be fitted just above the deluge valves to keep pressures within the above limits.

The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

6.5 Detection System

The installation and layout of detection system shall be governed by the layout of the water spray system. The detection network shall be similar to the sprayer network, namely, there shall be same number of detectors as there are number of sprayers.

The detection piping shall be independently supported as far as possible and care shall be taken not to support other pipes on detection network.

6.5.1 *Protection of Horizontal Cylindrical Storage Vessels*

Proposal for the protection of horizontal vessels shall be accompanied by full detailed dimensional working drawings showing the following:

a) Plan, elevation and end view.
b) Site plan showing the location of all vessels, their spacing, etc.
c) The protruberances such as valves, drains, manholes, flanges, ladders, supporting legs, etc.
d) Bund area and product pipes within.
e) Protection and detection piping in different colours.
f) Sprayer's characteristics showing the *K* factor, cone angle and discharge in litre per minute.

6.5.2 *General*

6.5.2.1 The complete exposed area of the horizontal storage vessel shall need to be protected at a uniform density of water application.

6.5.2.2 It is also necessary to protect the supporting legs and the product pipes within the bund area (if provided) by sprayers.

NOTES

1 Supporting steel members need not be protected if they are 300 mm or shorter in height.

2 Where tankage area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

3 Also other occupancies, such as, pump house, loading shed, etc, falling within 15 m of the tank shell shall be protected by the sprayers.

6.5.2.3 The protection network shall be fabricated in the form of horizontal rows of sprayers connected by piping, in rings. The number of rows required shall be governed by the diameter of the vessel, in accordance with the sprayer application charts C, D and E (*see* Fig. 4, 5 and 6).

6.5.2.4 The sprayers shall not be less than 6 mm in orifice size and shall normally have cone angles between 60° and 125°.

NOTE — Sprayers with cone angles below 60° are permissible for local protections, such as, supporting legs, protruberances, etc.

6.5.2.5 Minimum and maximum pressures in the network shall be 1.4 bars and 3.5 bars respectively.

6.5.2.6 'Run down' shall not be considered for horizontal vessels.

6.5.2.7 Sprayers shall be installed normal to the exposed area of the vessel and positioned at distances as per the sprayer application charts C, D and E (*see* Fig. 4, 5 and 6).

NOTE — Sprayers need not be installed normal to the surface for protecting the ends of the vessels.

6.5.2.8 Adequate provision shall be made to promptly and effectively dispose off, water discharged for fire fighting, cooling, etc, away from the vessels by any suitable means (*see* **4.6**).

6.5.2.9 Vessels shall be spaced at more than 15 m from each other. In such cases, the water demand for the largest vessel shall determine the pumping and water requirement. If this is contravened, the aggregate water demand for all such vessels falling within the prescribed distance of each other shall be the determining factor.

6.5.3 *System Design*

6.5.3.1 *Density of discharge*

Water shall be applied at a minimum density of 10.2 l/min/m^2 of the exposed area of the vessel. The supporting legs and product pipes within the bund shall also receive water at the same density.

NOTES

1 Supporting steel members need not be protected if they are 300 mm or shorter in height.

2 Where tankage area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

3 Where high wind velocity is expected, for example, near sea coasts, the sprayers protecting the tankages shall be necessarily installed at 0.45 m from the surface of the vessels.

6.5.3.2 *Distribution of sprayers*

a) Sprayers in horizontal rows shall be spaced at distances given below according to the angle selected.

LONGITUDINAL SPACING (METRES) OF SPRAYER OF VARIOUS DISCHARGE ANGLES

Angle	*Distance from Tank* m		
degree			
	0.65	0.55	0.45
60	0.90	0.80	0.70
65	1.00	0.85	0.70
70	1.05	0.90	0.70
75	1.15	1.00	0.85
80	1.25	1.05	0.90
85	1.35	1.15	1.00
90	1.45	1.25	1.05
95	1.60	1.35	1.15
100	1.70	1.45	1.20
105	1.85	1.60	1.30
110	2.00	1.70	1.45
115	2.20	1.90	1.55
120	2.40	2.05	1.70
125	2.65	2.25	1.90

NOTE — *See also* **6.5.2.3**.

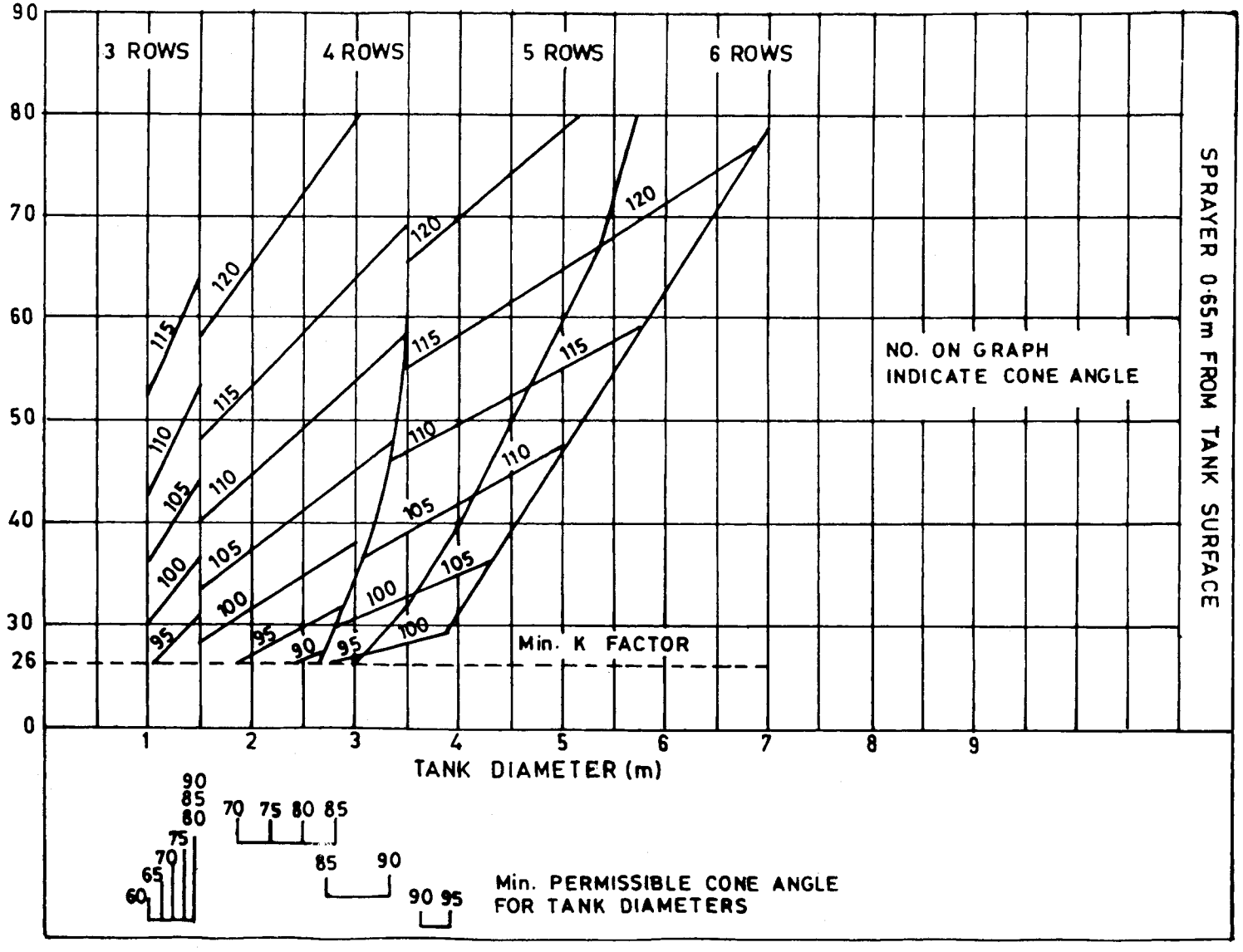

FIG. 4 SPRAYER APPLICATION CHART (C)

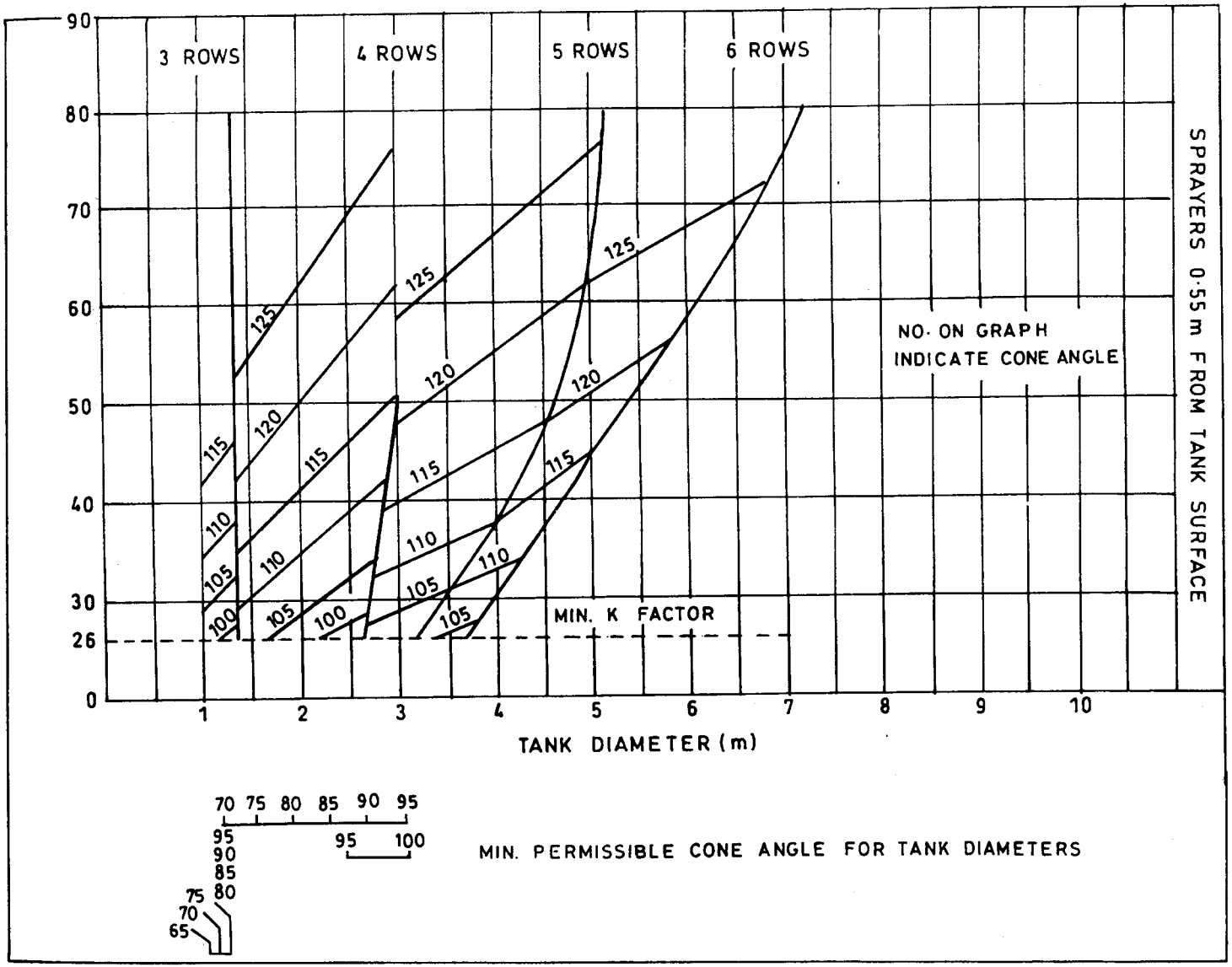

FIG. 5 SPRAYER APPLICATION CHART (D)

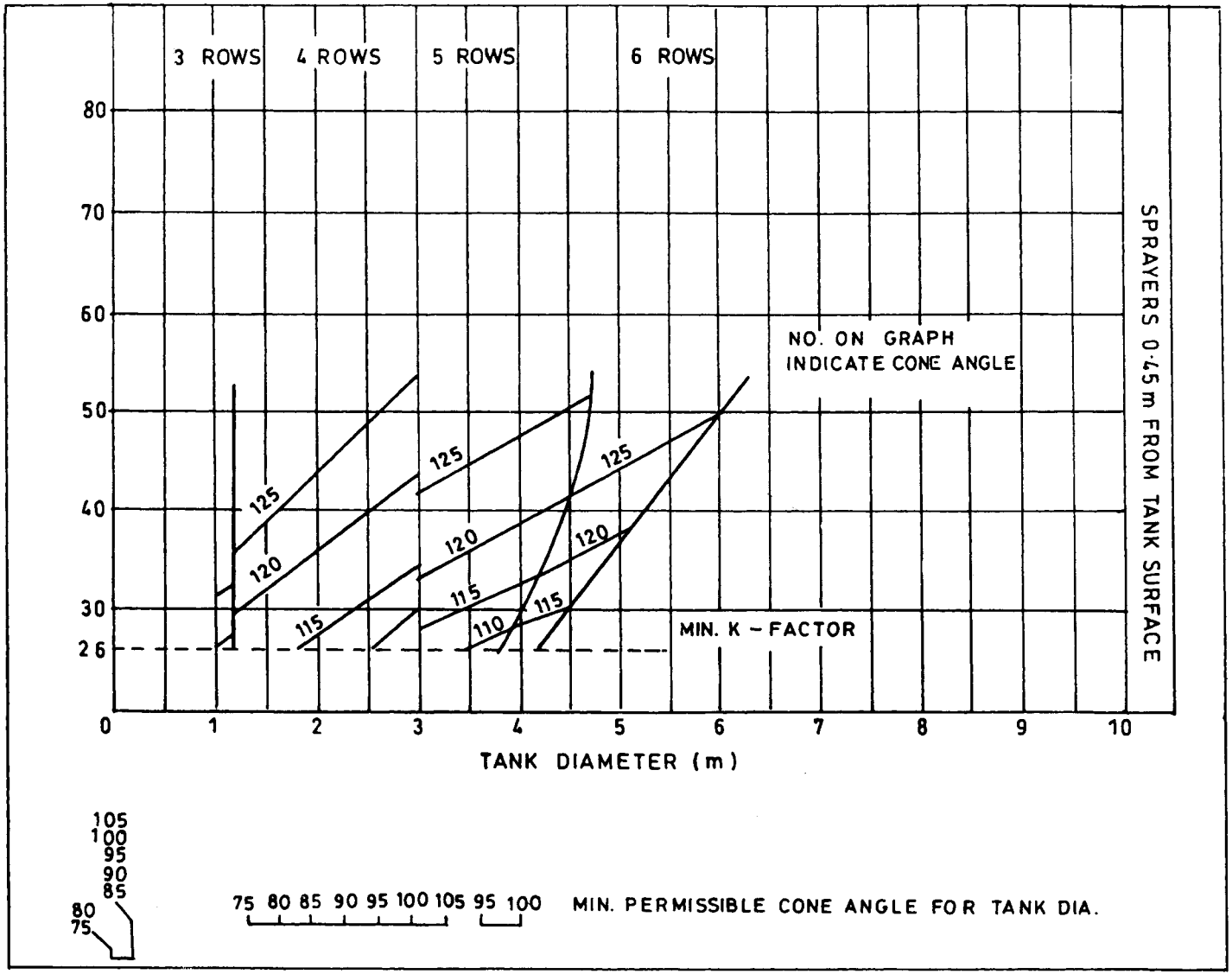

FIG. 6 SPRAYER APPLICATION CHART (E)

b) The sprayer application charts C, D and E relate '*K*' factors to vessel diameters for differing distances of sprayers to tank surface. Interpolation is permissible, if for some reasons the distances between sprayer and vessel surface cannot be adhered to.

NOTE — For a chosen angle, if a sprayer with a matching '*K*' factor is not available, next available higher '*K*' factor shall be used.

c) To provide adequate protection to the ends of the vessels, the following method shall be adopted.

6.5.3.3 *Flat ended vessels*

a) *Up to 5 m diameter* — The ends shall be adequately covered by half the flow from each end sprayer of all rows (*see* Fig. 7).

b) *More than 5 m diameter* — Arrangement as above plus an additional sprayer shall be located to aim on to the centre of the vessel (*see* Fig. 8).

6.5.3.4 *Hemispherical ended vessels*

a) *Up to 3.5 m diameter* — The ends shall be adequately covered by half the flow from each end sprayer of all rows plus one additional sprayer located to aim on to the centre of the vessel (*see* Fig. 9).

b) *More than 3.5 m diameter* — Arrangement as above plus an additional sprayer to provide correct density (*see* Fig. 10).

6.5.3.5 *Dished ended*

Average curved ended vessels:

a) *Up to 3.5 m diameter* — The ends shall be adequately covered by half the flow from each end sprayer of all rows (*see* Fig. 11).

b) *Between 3.5 m and 5 m diameter* — Arrangement as above, plus an additional sprayer shall be located to aim on to the centre of the vessel (*see* Fig. 12).

c) *Above 5 m diameter* — Arrangement as in **6.5.3.5** (b), plus additional sprayer to provide correct density (*see* Fig. 13).

6.5.3.6 Separate sprayers shall be installed to provide wetting of all protruberances from the vessel, such as, manholes, vents, flanges, relief valves, ladders, etc, in addition to the sprayers in rows and ends.

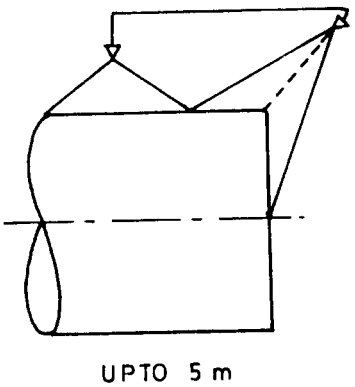

FIG. 7 FLAT ENDED TANKS COVERAGE OF TANK ENDS

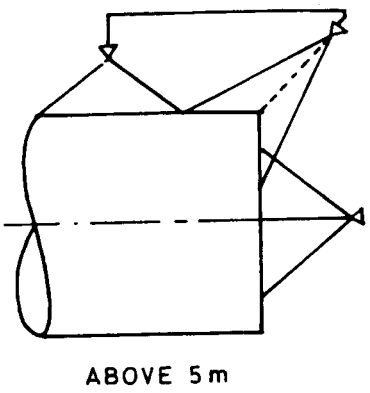

FIG. 8 FLAT ENDED TANKS COVERAGE OF TANK ENDS

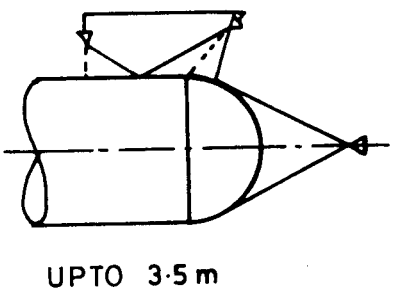

FIG. 9 HEMI-SPHERICAL ENDED TANKS

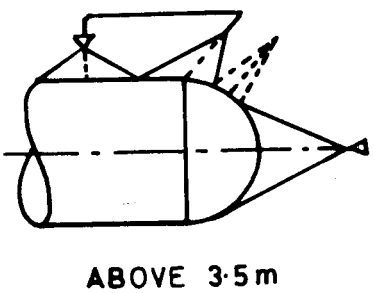

FIG. 10 HEMI-SPHERICAL ENDED TANKS

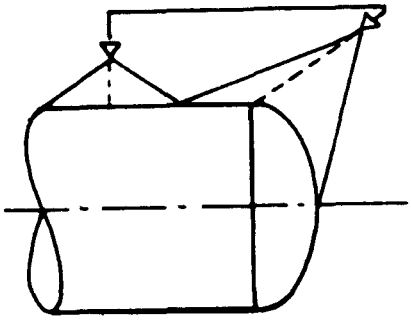

FIG. 11 AVERAGE CURVED ENDED TANKS

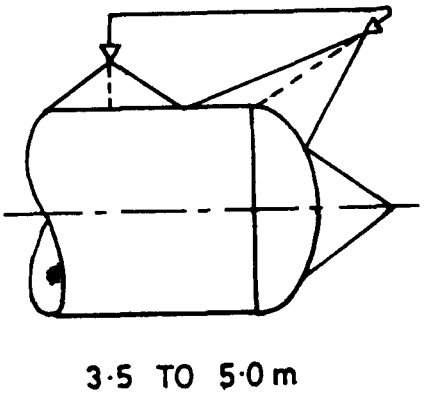

FIG. 12 AVERAGE CURVED ENDED TANKS

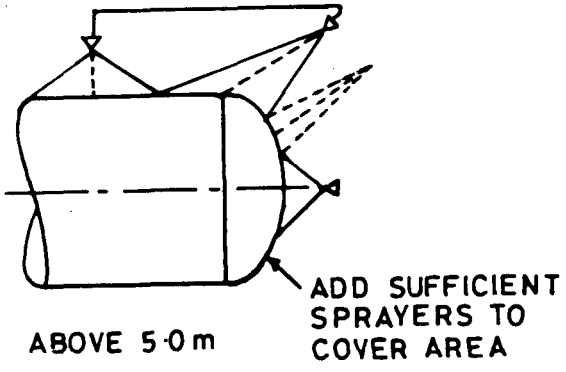

FIG. 13 AVERAGE CURVED ENDED TANKS

6.5.3.7 Unencased steel supports for the vessels if exceeding 300 mm in height shall be wetted by individual sprayers.

NOTE — Concrete and encased steel supports need not be wetted separately as they are likely to be wetted by the splash of water spray for the vessels.

6.5.3.8 Spacing of sprayer for product pipes within the bund shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes.

6.5.4 *Piping Layout and Supports*

6.5.4.1 The main feed pipes from the deluge valve feeding the network shall be supported at every 3.5 m of its run.

6.5.4.2 Vertical feed pipes shall be provided to establish flow from bottom rings to top rings at intervals not exceeding 3.5 m along the vessels. These pipes may also be used as supporting pipes for the network.

6.5.4.3 To ensure mechanical stability, good appearance and hydraulic gradient, the rings of pipe-work shall be of uniform size throughout each ring.

6.5.4.4 Where it is not possible to independently support the protection pipe-work, support can be arranged from the protected vessel if plate thickness of the vessel is adequate. In such case, rubber or plastic insertion shall be provided beneath the base of support to accommodate curvature of the vessel and to prevent corrosion.

6.5.4.5 The sprayers in the bottom ring shall point 45° upwards and water in the pipe-work shall never drain through the sprayers.

6.5.4.6 Where vertical feed pipes are used for supporting the network the pipes shall be braced together suitably at mid-heights to prevent buckling.

6.5.4.7 All vertical support pipes shall be fitted with non-ferrous or stainless steel cooling/drain/orifice plugs. The hole in the plug shall not be less than 3 mm diameter.

6.5.4.8 Vertical feed pipes when used as supporting pipes shall be flanged at the base and bolted securely to the ground.

6.5.4.9 For vessels longer than 10 m diameter, the network piping shall be so arranged that there is one feed pipe into the lower ring from the deluge valve for every 10 m and part thereof. It shall be ensured that each such segment serve an equal amount of protection for hydraulic balance.

6.5.5 *Pipe Work Hydraulics*

6.5.5.1 *Pre-calculated pipe sizing*

a) The diameters of pipes in top and bottom rings shall be as per Tables 2, 3 and 4.

   1) *Top Ring* — The size of pipe shall be as indicated in Table 2, provided the discharge from all sprayers between adjacent vertical feed pipes does not exceed the rates given in Table 2.

Table 2 Size of Pipe for Top Ring

[*Clause* 6.5.5.1(a)]

Sl No.	Nominal Flow to Largest Number of Sprayers Between Adjacent Vertical Feed Pipes	Nominal Diameter of Pipe
	l/min	mm
(1)	(2)	(3)
i)	0 to 100	25
ii)	Above 100 up to 160	32
iii)	Above 160 up to 250	40

2) *Bottom Ring* — The size of pipe shall be as indicated in Table 3, provided the discharge from all sprayers in one module of not more than 10 m long on top, bottom and through any drain points does not exceed the rates given in Table 3.

Table 3 Size of Pipe for Bottom Ring

[*Clause* 6.5.5.1(a)]

Sl No.	Average Flow	Nominal Diameter of Pipe
	l/min	mm
(1)	(2)	(3)
i)	260	25
ii)	440	32
iii)	680	40
iv)	1 040	50
v)	1 800	65
vi)	2 700	80

b) With the above arrangements, it shall be ensured that the running pressure at the points of feed from the deluge valve into the bottom ring is not more than that required to provide 3.5 bars pressure at the most favourable sprayer and not less than 1.4 bars plus an increment of 0.35 bar and static loss up to the most unfavourable sprayer. In other words, the pipe losses from the point of feed at the bottom ring up to the most unfavourable sprayer shall not exceed 0.35 bar apart from the static losses.

NOTE — While calculating the flow and pressure the discharge through cooling/drain plugs shall also be considered.

c) The horizontal pipe across the bottom ring and vertical feed pipes connecting bottom and top rings shall produce a velocity of not more than 10 m/s when sprayers discharge at their nominal rates. In no case, however, shall the vertical feed pipes be of a diameter less than that indicated in Table hereunder.

6.5.5.2 If pre-calculated system is not followed, the system shall be so designed that the hydraulically most unfavourable sprayer operates at a pressure of not less than 1.4 bars and the most favourable sprayer at a pressure of not more than 3.5 bars [*see* **6.5.5.1** (c)].

Table 4 Vertical Feed Pipe

[*Clause* 6.5.5.1(a)]

Sl No.	Length of Vertical from Ground	Nominal Diameter of Support and Feed Pipe
	m	mm
(1)	(2)	(3)
i)	Up to 3.0	40
ii)	Above 3.0 and up to 4.5	50
iii)	Above 4.5 and up to 6.0	65
iv)	Above 6.0 and up to 8.0	80

6.5.5.3 Orifice plates shall be provided if required, above the deluge valves to meet the conditions as above.

6.5.6 *Detection System*

6.5.6.1 Detectors shall be installed in horizontal rows along the vessels and there must be same number of rows as for the sprayers.

6.5.6.2 Spacing of detectors on rows shall not exceed 2.5 m.

6.5.6.3 The detectors shall be located at not more than 1 m from the shell.

6.5.6.4 Separate detectors shall be provided for proturberances from the shell like manholes, flanges, etc.

6.5.6.5 Detectors shall be so positioned that they will not interfere with the spray pattern of the sprayers anywhere.

6.5.6.6 One central row of detectors shall be allowed for two vessels with longitudinal axis parallel provided, **6.5.6.3** is not contravened. However, the vessels concerned shall be wetted simultaneously during a fire.

6.6 Protection of Vertical Cylindrical Storage Vessel

6.6.1 Proposals for the protection of the vertical vessels shall be cross-checked with full detailed drawings of the vessels showing the following:

a) Plan, elevation and end view;
b) Site plan showing the location of all vessels, their spacing, etc;
c) The protuberances, such as, valves, drains, manholes, flanges, ladders, etc;
d) Bund area and product pipes within;
e) Protection and detection piping in different colours; and
f) Sprayers characteristics showing the '*K*' factor cone angle and discharge in litre per minute.

6.6.2 *General*

6.6.2.1 The complete exposed area of the vertical storage vessel shall need to be protected at a uniform density of water application.

6.6.2.2 It is also necessary to protect the product pipes within the bund area (if provided) by sprayers.

NOTES

1 Where tankage area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

2 Also other occupancies such as pump house, loading shed, etc. falling within 15 m of the tank shell shall be protected by the sprayers.

6.6.2.3 The protection piping network shall be fabricated in the form of horizontal rings at regular intervals and vertical feeder mains.

6.6.2.4 The conical/flat roof shall also be protected by water spray system. For this purpose, sprayers shall be connected through an explosion relief valve assembly which enables sprayer piping on the top of the vessels to be blown off in the event of an explosion without obstructing the sprayers cooling the vertical sides.

6.6.2.5 Vertical mains shall be solely used as feeder mains only and sprayers shall be installed on the horizontal rings.

6.6.2.6 The sprayers shall not be less than 6 mm in orifice and shall normally have cone angles between 60° and 125° for vertical sides. For the conical roof/ flat roof, wider angle sprayers with higher '*K*' factor is recommended to reduce the number of sprayers and consequently the weight of piping over the tank.

NOTE — Sprayers with cone angles less than 60° are permissible for local protection, such as, protuberances.

6.6.2.7 Minimum and maximum operating pressures in the net work shall be 1.4 bars and 3.5 bars respectively.

6.6.2.8 'Run down' shall be considered provided there are no obstructions on the sides. For this purpose, sprayers with reduced orifice size shall be acceptable in the lower rings. The overall density of application shall however be maintained.

6.6.2.9 Sprayers shall be installed normal to the exposed area of the vessel and positioned at a distance of not less than 450 mm or not more than 650 mm from the surface.

6.6.2.10 Vessels shall be located in individual dykes and spaced 15 m (or the diameter of the largest tank if the same is more than 15 m) apart. In such cases, the water requirement of the largest vessel shall determine the pumping and storage requirements. However, if a number of tanks are located in a common dyke, the tanks located in a common dyke which have the largest aggregate shell surface area shall determine the pumping and storage requirements. In case of tanks located in separate dykes, but within a distance of 15 m (or diameter of the larger tank is less than 15 m) of each other, the shell surface area of all such tanks shall determine the pumping and storage requirements.

NOTE — In case occupancies like pump house, loading sheds, etc, exist within 15 m (or the diameter of the largest tank as the case may be) of the vessels, such occupancies shall also be protected by sprayers.

6.6.3 *System Design*

6.6.3.1 *Density of discharge*

Water shall be applied at a rate of not less than 10.2 l/min/m^2 of the exposed area of the tank shell and the roof. The product pipes within the bund shall also receive water at this density.

NOTES

1 Supporting legs if any, shall also receive water at the same density irrespective of whether they are insulated or not.

2 *See* **6.6.2.2**.

6.6.3.2 *Distribution of sprayers*

a) Sprayers shall be spaced at not more than 2.5 m in the rings when measured along the curved surface of the vessels.

b) There shall be a ring for every 3.5 m height of the shell.

c) Sprayers in each successive ring shall be staggered for better coverage.

d) Sprayers protecting the roof must be located in such a way that the extremities of their spray pattern shall at least meet.

e) Separate sprayers shall be installed to provide wetting of all protruberances from the vessels, such as manholes, flanges, ladders, vents, etc, and

f) Spacing of sprayers for product pipes within the bund shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes.

6.6.4 *Piping Layout and Supports*

6.6.4.1 The main feed pipes from the deluge valve feeding the network shall be supported at every 3.5 m of its run.

6.6.4.2 The number of vertical feeders for the sprayer network depends upon the size of the vessel and its height. As a good practice, minimum of two such feeders shall be provided. However, for the vessels less than 10 m diameter and height, one feeder shall be accepted.

6.6.4.3 The top ring shall be installed just below the top of the vessel and the bottom ring shall be installed at not more than 2 m from the ground level.

6.6.4.4 The rings may be supported on the vessel if plate thickness of the vessel is adequate. The vertical

feed mains shall also be used as supporting pipes. These pipes shall be flanged at the base and bolted securely to the ground.

6.6.4.5 The sprayers at the bottom ring shall point slightly upwards and water in the pipe work shall never drain through the sprayers.

6.6.4.6 All support pipes shall be fitted with non-ferrous or stainless steel cooling/drain orifice plugs. The hole in the plug shall not be less than 3 mm diameter.

6.6.5 *Hydraulics*

6.6.5.1 The network shall be hydraulically so designed as to provide a minimum running pressure of 1.4 bars at the hydraulically most unfavourable sprayer and not more than 3.5 bars at the hydraulically most favourable sprayer in the network.

6.6.5.2 The velocity in the feeder pipes shall not exceed 5 m/s when sprayers discharge at their nominal rates.

6.6.5.3 Orifice plate shall be provided if required, above the deluge valves to meet the conditions as above.

6.6.5.4 Flow through the cooling/draining pipes shall also be considered for the hydraulics.

6.6.6 *Detection System*

6.6.6.1 Detectors shall be installed in horizontal rows supported on the spray network if necessary and there must be as many detector rings as of spray rings.

6.6.6.2 Spacing of detectors in rings shall not be more than 3 m when measured along the curved surface of the vessel.

6.6.6.3 For conical roof the detector shall be installed on 9 m^2 area basis.

6.6.6.4 The detectors shall be located at not more than 1 m from the shell.

6.6.6.5 Separate detectors shall be provided for protruberances like manholes, flanges, etc.

6.6.6.6 Detectors shall be so positioned as not to interfere with the sprayer pattern of the sprayers anywhere.

6.7 Protection of Spherical Vessels

6.7.1 *General*

6.7.1.1 Spherical vessels are almost certain to be pressure vessels. The complete exposed area sphere shall need to be protected at a uniform density of water application.

6.7.1.2 It is also necessary to protect the supporting legs and the product pipes within the bund area by the water spray system at the same density and where bund is not provided, product pipe lines shall be protected for a distance of 15 m from the surface of the sphere.

6.7.1.3 The protection network around such vessels shall be fabricated in the form of horizontal and/or vertical rings at regular intervals.

6.7.1.4 The sprayers shall not be less than 6 mm in orifice size and shall normally have cone angles between 60° and 125° for the spherical surface.

6.7.1.5 Minimum and maximum pressures in the network shall be 1.4 bars and 3.5 bars respectively.

6.7.1.6 'Run down' shall not be considered.

6.7.1.7 Sprayers shall be normal to the exposed surface of the sphere and shall be installed at not less than 550 mm or more than 650 mm from the surface.

6.7.1.8 Spheres shall be spaced at a distance of 15 m from each other. In such cases the water demand for a larger sphere shall determine the pumping and storage requirements. If the spheres are spaced less than 15 m apart, the aggregate water demand of all the spheres falling within the prescribed distance of each other shall be the determining factor.

6.7.1.9 Full detailed dimensional drawing of the spherical vessels shall be cross-checked with the following details before designing the system:

a) Plan, elevation;
b) Site plan showing all the spheres;
c) The protruberances such as valves, drains, manholes, flanges, ladders, supporting legs, etc;
d) The protection/detection piping in different colours; and
e) Sprayer characteristic showing '*K*' factor, cone angle and discharge in litre per minute.

6.7.2 *System Design*

6.7.2.1 *Density of discharge*

Water shall be applied at a minimum density of 10.2 l/min/m^2 of the exposed area of the sphere. The supporting legs and the product pipes within the bund area shall also receive water at the same density. Where bund is not provided, the product pipelines up to a distance of 15 m from the surface of the sphere, shall receive water at the same density.

NOTE — If the supporting legs are encased with 50 mm thick R.C.C., the water density therefore can be reduced to 5.1 l/min/m^2.

6.7.2.2 *Distribution of sprayers and lay-out of piping*

a) No sprayer shall be farther than the distance '*S*' indicated in cases 1 or 2 (*see* Fig. 14 and 15), from anyone of the nearest 8 sprayers. The distance between sprayers shall be measured along the arcs between the points of impingement of the sprayers on the tank surface.

b) The spacing '*S*' between the sprayers for various diameters of the sphere for different cone angles of sprayers shall be selected from the charts F and G (*see* Fig. 16 and 17).

c) Obstructed or 'roofed off' portions of the spheres shall be protected with separate sprayers in addition to the requirements under **6.7.2.2**(b) above at a density of 10.2 l/min/m^2.

d) Number of horizontal and/or vertical rings shall be governed by the spacing of the

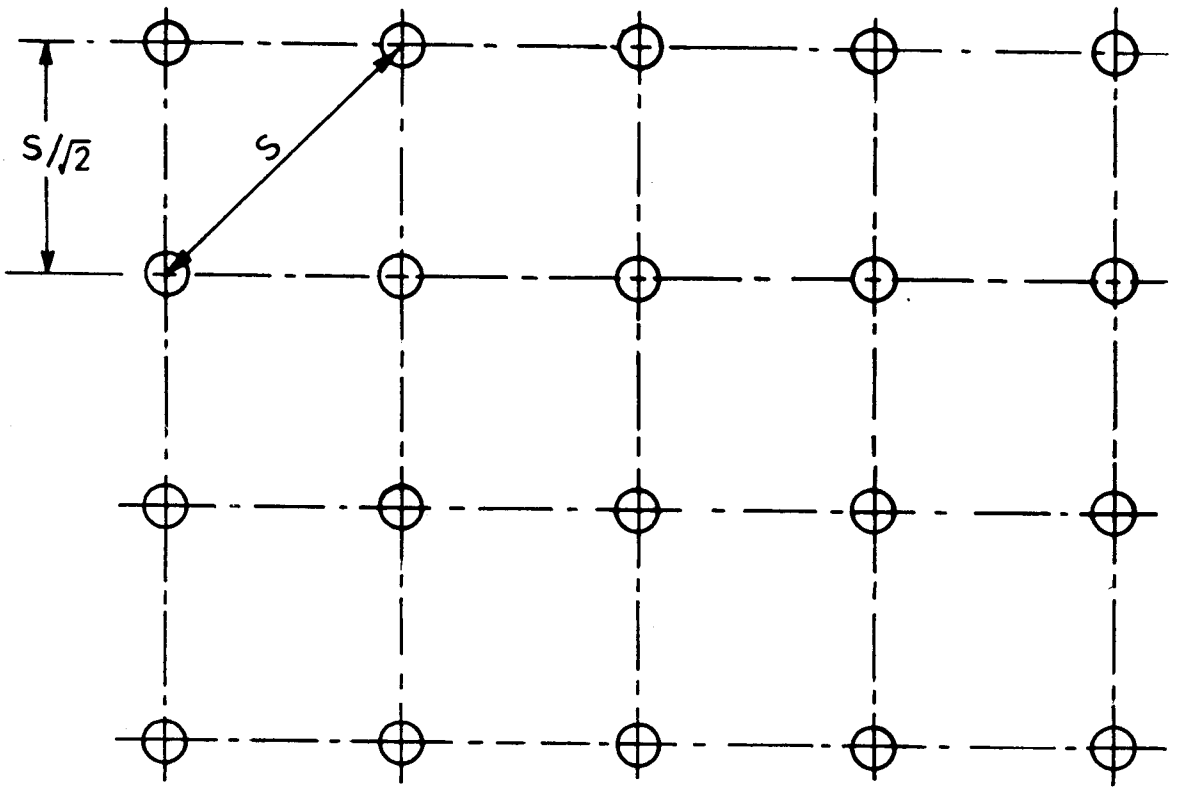

FIG. 14 DISTRIBUTION OF SPRAYERS

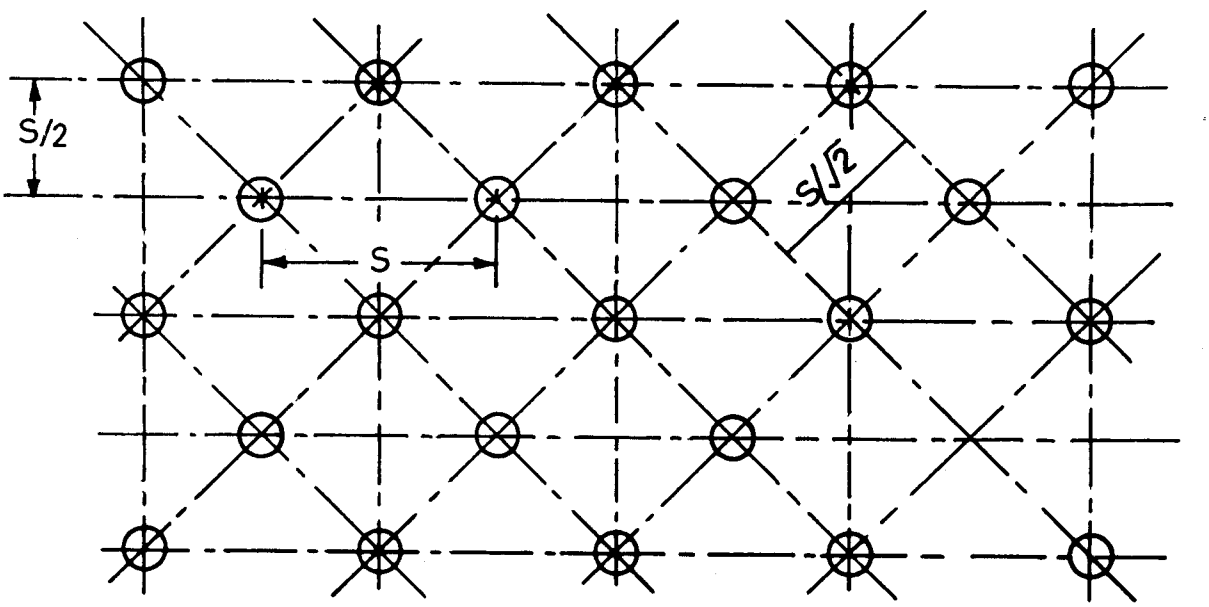

FIG. 15 LAYOUT OF PIPING

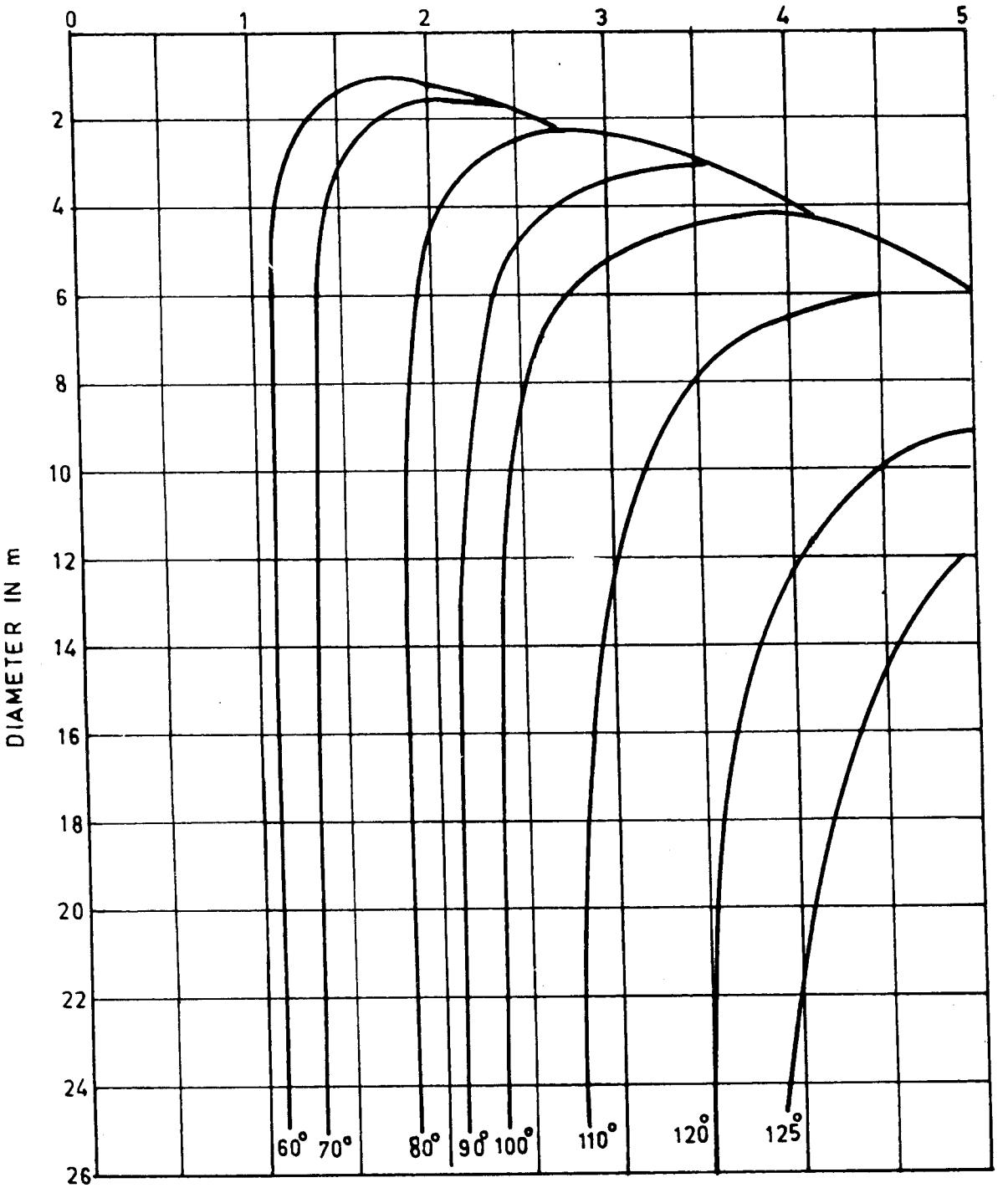

FIG. 16 MAXIMUM SPACING BETWEEN ADJACENT SPRAYERS IN m (CHART F)

sprayers [(*see* **6.7.2.2**(b)].

e) The system shall be hydraulically designed in such a way that the pressure at the hydraulically most unfavourable sprayer shall not be less than 1.4 bars while that at the hydraulically most favourable sprayer shall not exceed 3.5 bars. The difference in height between the top and bottom sprayers may be compensated by reducing sprayer orifice and/or other means to achieve even distribution of water on the surface. The velocity produced in the feeder pipes shall not exceed 10 m/s.

f) Cooling system for protecting the sphere against solar heating shall take the form of minimum two rings of sprayers at the top of the spheres up to 10 m diameter and three

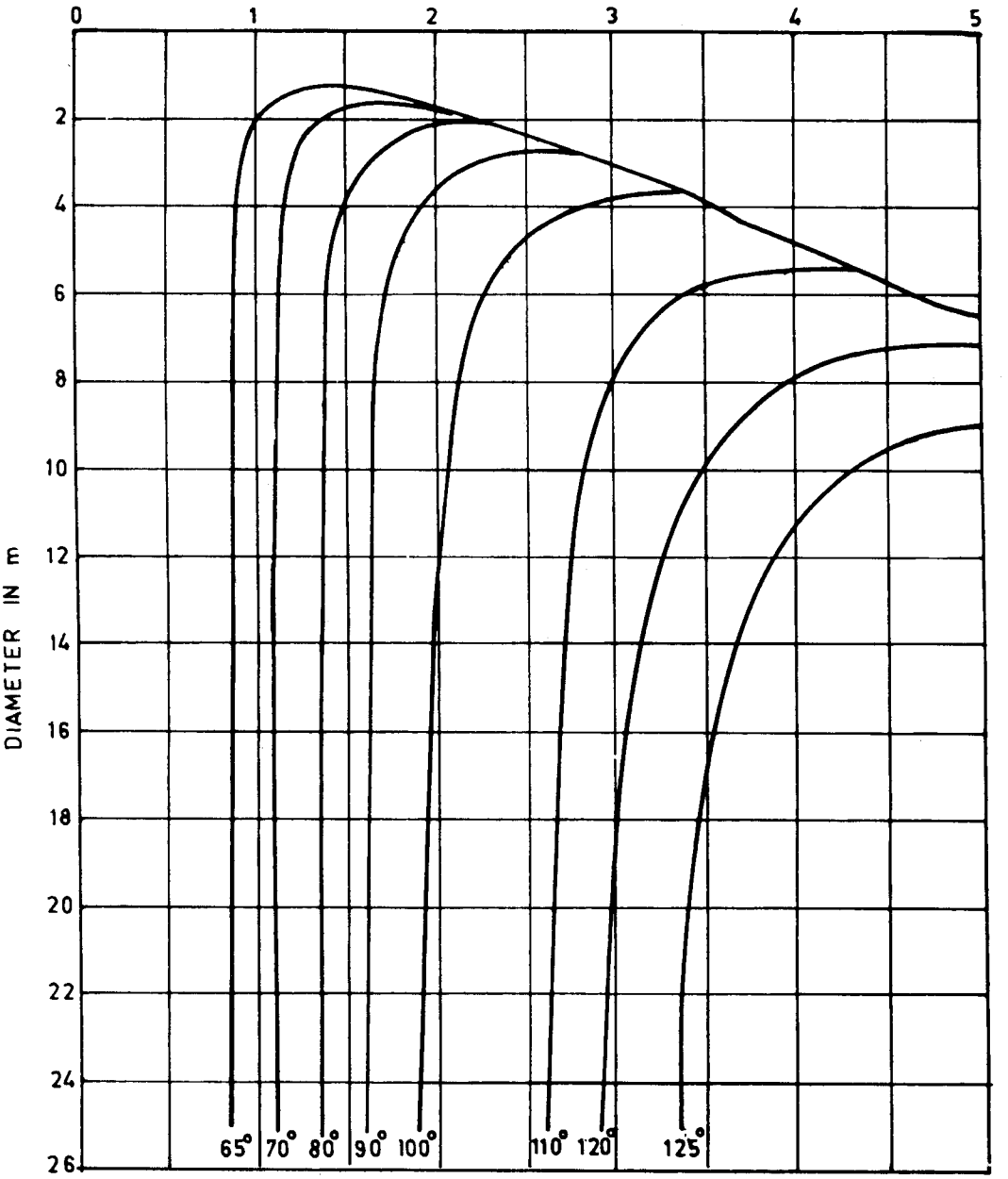

FIG. 17 MAXIMUM SPACING BETWEEN ADJACENT SPRAYERS IN m (CHART G)

rings of sprayers at the top of the sphere exceeding 10 m diameter at a density not less than 2 l/min/m².

NOTE — It is not considered necessary to wet the surface of the sphere below the horizontal centre line when considering solar protection.

g) Spacing of sprayers for the product pipelines shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes.

6.7.3 *Pipe Support*

6.7.3.1 The pipe work on the top of hemisphere of the vessel shall rest on the surface and an adequate number of support points shall be required to distribute the weight uniformly on the surface.

6.7.3.2 The pipe work below the hemisphere shall be supported separately from the ground or the legs supporting the sphere. The legs shall be designed to take care of this load.

6.7.3.3 Where supports rest on the surface of the sphere, a rubber or plastic insertion shall be provided beneath the base of the support and the sphere surface to accommodate the curvature of the sphere as well as to prevent corrosion.

6.7.3.4 Where the vessel is insulated, supports shall have to either penetrate the lagging or provided on the lagging itself. In either case, greater care shall have to be taken to adequately spread the load and efficiently seal the penetrated area of the lagging after supports are installed.

6.7.4 *Detection System*

6.7.4.1 It is not necessary to provide detector sprinklers for the whole surface of the sphere. Detectors at three levels shall suffice as follows:

a) A minimum of three under the lower pole adjacent to product piping.
b) A ring of detectors at the equator or just below. The detectors shall be installed at not more than 2.5 m of the circumference of sphere.
c) A minimum of three detectors at the upper crown of the sphere in the advantageous position near relief valves, vents, etc.

6.7.4.2 The detector shall be suitably supported, if required on sprayer piping.

6.7.4.3 The detector shall, in any case, be installed at not more than 300 mm from the surface protected.

6.7.4.4 Detector shall also be installed near the product pipes within the bund area at every 2.5 m and where no bund is provided the detectors shall be installed up to 15 m from the shell surface of the sphere.

6.8 Cable Galleries and Tunnels

6.8.1 *General*

Where cable fires are concerned, the greatest hazard usually arises from the effects of fire on the power station plant. However, a feature of practically all cable fires has been that several units, if not the whole station, has been seriously affected by a single fire. A major portion of cable fire incidents stem from external sources such as combustion of uncleaned flammable debris, accumulation of PVC tailing ends, cardboard packages and from uncontrolled spillages and over spray of fuel and lubricating oils.

PVC is not readily flammable but will burn freely in temperature conditions high enough to bring chloride toxic gases which are heavier than air and tend to form layers at lower levels. These gases are corrosive and presents a major toxic hazard to operating and fire fighting personnel. When PVC is burnt, heavy black smoke, mostly consisting of carbon particles is given off which could affect electrical equipment some distance from the fire and there is some evidence that PVC smoke can, de-sensitize smoke detectors of ionization chamber type.

Cables are normally protected such that they do not catch fire if electrical faults develop in them. However, the energy released when a fault occurs in a cable may ignite other combustible materials in the vicinity thereof.

6.8.2 *Design Density*

Water shall be applied at a minimum density of 12.2 l/min/m^2 of the exposed area of the cable racks.

NOTE — For the purpose of the above, three cable trays of a rack shall be reckoned as a single tray unless the trays are not of the same width in which case the area of the widest tray shall be taken.

6.8.3 *Pressure Requirement*

In order to achieve a better penetration, a minimum pressure of 2.8 bars shall be achieved at the hydraulically remotest point.

6.8.4 *Distribution of Sprayers and Lay-out of Piping*

6.8.4.1 The sprayers shall be installed in rows at ceiling level in between and at the centre of aisle space along the cable trays and spaced at not more than 3 m.

6.8.4.2 The distance between walls and/or limits of the protection shall not exceed 1.5 m.

6.8.4.3 Where the distance between two rows of sprayers above the aisles exceeds 4 m, additional row of sprayers shall be provided in between.

6.8.4.4 Where the height of the cable trays (that is, distance between topmost and bottom tray) exceeds 2.5 m, sprayers shall be provided at lower level in accordance with **6.8.4.3**.

6.8.5 *Piping and Hydraulics*

6.8.5.1 Installation of piping shall be carried out in general as detailed in **6.4.7**.

6.8.5.2 It is permissible to divide the protection area into several zones, each of which shall be fed by an individual deluge valve. The flow through the deluge valve shall be limited to the values given in **4.5.2** (h). The system shall be designed in such a way that at least two zones shall operate simultaneously in the event of fire.

6.8.5.3 Each zone in the system shall be hydraulically so designed that a minimum pressure of 2.8 bars is available at the remotest sprayer and that the velocity produced in the feeder pipes is not more than 10 m/s.

6.8.6 *Pumping Capacity and Water Supplies*

6.8.6.1 The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

6.8.6.2 The effective exclusive capacity of the

reservoir/tank (above the level of the foot valve seat in case of negative suction and above the level of the top of the pump casing in case of positive suction) shall not be less than 40 min aggregate pumping capacity for the spray system.

6.8.7 *Detection System*

As the cable galleries and tunnels are normally unmanned, it is imperative that a quicker detection is mandatory to ensure extinguishment. Various types of detectors are available for installation in the tunnels. The following methods of detection in the order mentioned are generally accepted:

a) Linear heat sensing cables,
b) Smoke detectors, and
c) Sprinkler heads.

Full details of the proposal shall be submitted in advance alongwith detailed drawings showing the location and lay-out of the detection network.

The fire alarm system and panel shall be of approved type.

6.9 Conveyors

6.9.1 *General*

Fires on conveyors are infrequent but the fire potential is considerable. In incidents which have occurred, the damage has been severe, particularly where conveyor fires have reached and enveloped the destination, for example, boiler house coal bunkers as in case of thermal power stations. The design of conveyors is that the wind tunneling or chimney effect is an inherent feature on inclined conveyors and this causes rapid spread of fire through the conveyors.

The major risk of fire is, for example, from the ignition of coal dust and deposits in case of thermal power stations, on the internal surface, walk always, etc, of the conveyors or from the conveyor belt. Fire caused by friction of a defective part such as jammed roller, idlers resulting in subsequent localized overheating of the belt. Thus fires in the conveyors may arise from either of two main causes:

a) Failure of part of the mechanism, usually on the idler or pulley can lead to localized overheating of the belt and eventually to ignition of the combustible dust or conveyor belt.
b) From the ignition of a quantity of split combustible dust either by self ignition or other causes.

Should the belt catch fire, it can spread the fire rapidly to other areas. Certain fires generate a large volume of smoke particularly when the fire is in advanced state, conveyors can be protected by automatic sprinkler system installation or medium velocity water spray system with L.H.S. cables, sprinkler bulbs, thermocouples, etc. The following requirements are for water spray systems only.

6.9.2 *Design Density*

Water shall be applied at a minimum density of 10.2 l/min/m^2 of the exposed area of the conveyor.

6.9.3 *Pressure Requirement*

A minimum pressure of 1.4 bars shall be achieved at the hydraulically remotes sprayer. However, pressure at the hydraulically favourable sprayer shall not exceed 3.5 bars.

6.9.4 *Distribution of Sprayers and Lay-out of Piping*

6.9.4.1 The sprayers shall be installed in rows at the ceiling level above the centre of each conveyor belt and spaced at not more than 4 m.

6.9.4.2 The distance between walls and/or limits of the protection shall not exceed 2 m.

6.9.4.3 Where the distance between two rows of sprayers above the centre of belts exceeds 4 m, additional rows shall be provided in between.

6.9.4.4 Sprayers shall be provided for the protection of the bottom side of the conveyors and these shall be spaced at 4 m on either side of the conveyor. Staggering of sprayers is recommended.

6.9.5 *Piping and Hydraulics*

6.9.5.1 Installation of piping shall be carried out, in general, as detailed in **6.4.7**.

6.9.5.2 It is permissible to divide the protection area into several zones, each of which shall be fed by an individual deluge valve. The flow through the deluge valve shall be limited to the values given in **4.5.2** (h). The system shall be designed in such a way that at least two adjacent zones shall operate in the event of fire.

6.9.5.3 Each zone in the system shall be hydraulically so designed that a minimum pressure of 1.4 bars is available at the remotest sprayer and that nowhere in the system exceeds 3.5 bars. The velocity produced shall not exceed 10 m/s.

6.9.5.4 Detailed hydraulic calculations in support of the above shall be submitted for each zone. Orifice plates, if required, shall arise out of combination of deluge valves when zones concerned operate simultaneously.

6.9.6 *Pumping Capacity and Water Supplies*

6.9.6.1 The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

6.9.6.2 The effective exclusive capacity of the reservoir/tank (above the level of the foot valve seat in case of negative suction and above the level of the top of the pump casing in case of positive suction) shall not be less than 60 min aggregate pumping capacity for the spray system.

6.9.7 *Detection System*

Detection of conveyor fires poses peculiar problems as the fires are not always stationary. Detection of moving fires shall be achieved without delay. The detectors upon sensing the fire shall trip the conveyor motor first and thus make the fire stationary. This fire has to be detected and the detectors shall trigger the fire fighting operations. Hence there are two levels of detection for the conveyor fires. The following methods of detection are generally acceptable:

a) Liner heat sensing cables — for stopping conveyor, and
b) Sprinkler bulbs.

Full details of the proposal shall be submitted in advance alongwith detailed drawings showing the location and lay-out of the detection network.

The fire alarm system and panel shall conform to IS 2189.

7 COMMISSIONING TESTS

7.1 Pre-commissioning and Acceptance Tests

7.1.1 All new system piping up to the deluge valve shall be hydrostatically tested to a pressure equivalent to 150 percent of the designed head of the fire pump and the system shall be capable of withstanding that pressure for at least 2 h.

NOTE — The piping above deluge valves need not be hydraulically tested.

7.1.2 The coating and wrapping of the underground wrought or mild steel pipes shall be carried out and also subjected to 'Holiday test' as per IS 10221.

7.1.3 The entire system piping shall be flushed thoroughly before commissioning in order to remove foreign materials which might have entered/be present in the system piping during the course of installation or which may have been present in existing piping at maximum flow rate available to the system under fire condition. When planning the flushing operations, consideration shall be given to disposal of the water discharged during flushing.

7.1.4 Full discharge test with water shall be made as a means of checking the nozzle layout, discharge pattern, spray coverage and obstructions and determination of relation between design criteria and actual performance and to ensure against clogging of the smaller piping and discharge devices by foreign materials.

7.1.5 The maximum number of systems (deluge valves) that may be expected to operate in case of fire shall be in full operation simultaneously in order to check the adequacy and condition of water supply.

7.1.6 The detection system shall be designed to cause actuation of special water control valve within 20 s under expected exposure conditions. Under test conditions the heat detector systems, when exposed to a standard heat source, shall operate within 40 s. Under test conditions the flammable gas detector system, when exposed to a standard test gas concentration, shall operate within 20 s.

NOTE — One method of testing heat detectors is to use a radiant heat surface at a temperature of 15°C and a capacity of 350 W held at a distance of 25 to 30 mm from the nearest part of the detector. This method of testing with an electric test set should not be used in hazardous locations. Other test methods may be employed but results shall be related to those obtained under these conditions.

7.1.7 All operating parts of the system including manual over-ride like emergency pull switch of the deluge valve shall be fully tested to ensure that they are in operating condition.

7.1.8 The discharge pressure at the highest, most remote nozzle and the lowest nozzle close to the deluge valve shall be measured which should be within the designed limits of the system. For this purpose provisions shall be made for test gauges at appropriate places.

7.1.9 The proper functions of the alarm gong associated with the deluge valve and its level of audibility shall be checked. An audibility level of 85 dB above the background noise level is recommended.

7.2 Periodical Testing and Maintenance

7.2.1 *General*

7.2.1.1 Water spray systems require competent and effective care and maintenance to assure that they will perform their purpose effectively at the time of fire. Systems shall be serviced and tested periodically by personnel trained in this work. An inspection contract with a qualified agency for service, test, and operation at regular intervals is recommended.

7.2.1.2 Operating and maintenance instruction and layouts shall be available or can be posted at control equipment and at the fire station of the plant. Selected plant personnel shall be trained and assigned the task of operating and maintaining the equipment.

7.2.1.3 At weekly, or other frequent, regular scheduled plant inspection, equipment shall be checked visually for obvious defects, such as broken or missing parts, external loading or other evidence of impaired protection.

7.2.1.4 At least once a week the system shall be visually checked and the reading of various pressure gauges of

each deluge valve installations shall be recorded.

7.2.1.5 A trained pumpman shall be available on all shifts and at all hour to operate the pump or whenever required.

7.2.2 *Fire Water Reservoirs/Tank*

7.2.2.1 It shall be ensured that fire water tank reservoirs are always full and free from any foreign materials. The water level shall be recorded weekly.

7.2.2.2 Depending upon quality of water, reservoirs shall be cleaned once in a year or two years and sludge formation shall be prevented.

7.2.3 *Fire Pumps*

7.2.3.1 All the fire pumps shall be run at least 5 min everyday. During testing water level of priming tank, delivery pressures of pumps, speed, and also other parameters are to be checked and recorded.

7.2.3.2 All pump glands shall be maintained in good working conditions and checked weekly.

7.2.3.3 The bearing grease caps shall be checked once every week and refilled with fresh grease, if necessary.

7.2.3.4 Starter contacts shall be cleaned every week.

7.2.3.5 Insulation resistance of pump motors shall be examined once in every six months and record shall be maintained.

7.2.3.6 Starting mechanism of diesel engine must be checked, the battery charger and also the batteries must be maintained in effective conditions and the engine shall be run at least for 5 min every day.

7.3 Periodical Testing and Maintenance Chart

Sl No.	*Subject*	*Activities*	*Duration*
i)	Reservoir	Level checking clearing	Weekly Once in two years
ii)	Pump	Running test	Daily 5 min
		Test flow	Annually
		Lubrication	Quarterly
		GI and packing	Weekly
		Overhaul	Once in two years
iii)	Engine	Running	Once in day (5 min)
		Lubrication	Quarterly
		Battery	Weekly
		Load test	Annually
		Overhaul	Once in two years
		Fuel tank check	Daily
iv)	Motor	Lubrication	Weekly
		Starter contact checking	Weekly
		Insulation resistance check	Half yearly
v)	Main piping	Flushing	Once in two years
		Guage pressure	Check Daily
vi)	Sluice valves	Operation	Monthly
		Gland packing	Monthly
		Lubrication	Muarterly
vii)	Deluge valves	Operation	Weekly
		Alarm check	Weekly
		Overhaul	Annually
		Cleaning	Quarterly
viii)	Sprayer	Cleaning	Quarterly
		Flow test	Quarterly
ix)	Detectors	Performance	Six monthly
x)	Spray installation	Performance	Quarterly
		Physical check up of piping for seeing dislocation of support, wrong orientation overloading, etc	Monthly
xi)	Pressure gauges	Calibration	Annually
xii)	Painting of entire installation	—	Every two years

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*	*IS No.*	*Title*
5 : 1994	Colours for ready mixed paints and enamels (*fourth revision*)	1879 : 1987	Malleable cast iron pipe fittings (*second revision*)
1239 : 1990	Mild steel tubes, tubular and other wrought steel fittings:	1978 : 1982	Line pipe (*second revision*)
(Part 1) : 1990	Mild steel tubes (*fifth revision*)	2189 : 1988	Code of practice for selection, installation and maintenance of automatic fire detection and alarm system (*second revision*)
(Part 2) : 1992	Mild steel tubular and other wrought steel pipe fittings (*fourth revision*)		
1536 : 1989	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage (*third revision*)	3589 : 2001	Steel pipes for water and sewage (168.3 to 2 540 mm outside diameter) (*second revision*)
1537 : 1976	Vertically cast iron pressure pipes for water gas and sewage (*first revision*)	7181 : 1986	Horizontally cast iron double flanged pipes for water, gas and sewage (*first revision*)
1538 : 1993	Cast iron fittings for pressure pipes for water, gas and sewage (*third revision*)	10221 : 1982	Code of practice for coating and wrapping of underground mild steel pipelines

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Fire Fighting Sectional Committee, CED 22

Organization	*Representative(s)*
Ministry of Home Affairs, New Delhi	SHRI OM PRAKASH (***Chairman***) SHRI D. K. SHAMI (*Alternate*)
Airport Authority of India, New Delhi	SHRI L. C. GUPTA SHRI H. S. RAWAT (*Alternate*)
Andhra Pradesh Fire Services, Hyderabad	SHRI SWARANJIT SEN
Bhabha Atomic Research Centre, Mumbai	CHIEF FIRE OFFICER
Bombay Fire Brigade, Mumbai	CHIEF FIRE OFFICER SHRI G. S. SAWANT (*Alternate*)
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Central Industrial Security Force, New Delhi	DEPUTY INSPECTOR GENERAL (FIRE) SHRI S. L. NAGARKAR (*Alternate*)
Central Public Works Department, New Delhi	CHIEF ENGINEER (~~E~~)
Centre for Environment and Explosive Safety, Delhi	SHRI A. K. KAPOOR SHRI H. S. KAPARWAN (*Alternate*)
Concord Arai Pvt Limited, Chennai	SHRI R. RAMAKRISHNAN
Controllerate of Quality Assurance (Fire), Pune	COL G. P. KRISHNAMURTHY
Defence Research and Development Organization, Delhi	DIRECTOR (FIRE SAFETY) DEPUTY DIRECTOR (FIRE SAFETY) (*Alternate*)
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Engineer-in-Chief's Branch, New Delhi	SHRI R. A. DUBEY SHRI AJAY SHANKAR (*Alternate*)
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Institution of Fire Engineers (India), New Delhi	PRESIDENT GENERAL SECRETARY (*Alternate*)
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K.V. Fire Chemicals, Navi Mumbai	SHRI H. M. SABADRA
Loss Prevention Association of India, Mumbai	MANAGING DIRECTOR SHRI D. K. SARKAR (*Alternate*)
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Safex Fire Services Limited, Mumbai	SHRI JITENDRA SHAH SHRI SANDIP SHAH (*Alternate*)

(*Continued on page* 36)

(*Continued from page* 35)

Organization	*Representative(s)*
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State Fire Training Centre, Mumbai	DR NAVINCHANDRA JAIN
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West Bengal Fire Service, Kolkata	SHRI B. PATHAK
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Member Secretary
SHRI S. CHATURVEDI
Joint Director (CED), BIS

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Review of Indian Standards

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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