ENGINEERING STANDARD

FOR

FIRE-FIGHTING SPRINKLER SYSTEMS

CONTENTS :

PAGE No.

0. INTRODUCTION

"Fire Fighting and Fire Protection Systems" are broad and contain variable subjects of paramount importance therefore, a group of engineering standards are prepared to cover the subject. This group includes the following standards:

STANDARD CODE	STANDARD TITLE
IPS-E-SF-120	"Off-Shore Installations Fire Fighting & Fire Protection"
IPS-E-SF-140	"Foam Generating and Proportioning Systems"
IPS-E-SF-160	"CO_2 Gas Fire Extinguishing Systems"
IPS-E-SF-180	"Dry Chemical Fire Extinguishing Systems"
IPS-E-SF-200	"Fire Fighting Sprinkler Systems"
IPS-E-SF-220	"Fire Water Distribution and Storage Facilities"
IPS-E-SF-240	"Fire Water Pump Systems"
IPS-E-SF-260	"Automatic Detectors and Fire Alarm Systems"
IPS-E-SF-280	"Telecommunication for Fire Fighting Operations"
IPS-E-SF-300	"Application of Breathing Apparatus in Safety and Fire Fighting"
IPS-E-SF-320	"Tugs, Fire-Fighters and other Off-Shore Harbor Vessels"
IPS-E-SF-340	"Fire Fighting Hose Box and/or Shelter "

This Standard covers:

"FIRE FIGHTING SPRINKLER SYSTEMS"

1. SCOPE

This Standard provides the minimum requirements for the design of fire sprinkler systems in buildings and industrial plant, and open head deluge-type, foam-water sprinklers and foam-water spray systems.

It covers the classification of hazards, provision of water supplies, and components to be used.

Note:

All pressures are gage pressures and are expressed in bars.
1 bar = 10^5 N/m^2 = 10^2 kPa.

2. SOURCES

In preparation of this standard, the following standards and publications have been considered:

BSI (BRITISH STANDARDS INSTITUTION)

BS 5306 Part 2 " Specification for Sprinkler System"

NFC (NFPA) (NATIONAL FIRE CODES)

NFC Volume 1 " Installation of Sprinkler Systems"
Sections 13 and 16

3. DEFINITIONS AND TERMINOLOGY

For the purposes of this standard the following definitions apply.

3.1 Accelerator

A device that reduces the delay in operation of a dry alarm valve, or composite alarm valve in dry mode, by early detection of the drop in air pressure when a sprinkler operates.

3.2 Alarm Test Valve

A valve through which water will be drawn to test the operation of the water motor fire alarm and/or of any associated electric fire alarm.

3.3 Alarm Valve

A check valve, of the wet, dry or composite type, that also initiates the water motor fire alarm when the sprinkler installation operates.

3.4 Alarm Valve, Composite

An alarm valve suitable for a wet, dry or alternate installation.

3.5 Alarm Valve Dry

An alarm valve suitable for a dry installation; and/or in association with a wet alarm valve for an alternate installation.

3.6 Alarm Valve, Pre-Action

An alarm valve suitable for a pre-action installation.

3.7 Alarm Valve, Recycling

An alarm valve suitable for a recycling installation.

3.8 Alarm Valve, Wet

An alarm valve suitable for a wet installation.

3.9 Arm Pipe

A pipe, other than the last section of a range pipe, feeding a single sprinkler.

3.10 Assumed Maximum Area of Operation (AMAO)

The maximum area over which it is assumed, for design purposes, that sprinklers will operate in a fire.

3.11 Assumed Maximum Area of Operation, Hydraulically most Favorable Location

The location in a sprinkler array of an AMAO of specified shape at which the water flow is the maximum for a specific pressure.

3.12 Assumed Maximum Area of Operation, Hydraulically most Unfavorable Location

The location in a sprinkler array of an AMAO of specified shape at which the water supply pressure is the maximum needed to give the specified design density.

3.13 Booster Pump

An automatic pump supplying water to a sprinkler system from an elevated private reservoir or a town main.

3.14 Cut-Off Sprinkler

A sprinkler protecting a door or window between two areas only one of which is protected by sprinklers.

3.15 Deluge Installation

An installation or tail-end extension fitted with open sprayers and either a deluge valve or a multiple control arrangement so that an entire area is sprayed with water on operation of the installation.

3.16 Deluge Valve

A valve suitable for use in a deluge installation.

Note:

The valve is operated manually and usually also automatically by a fire detection system.

3.17 Design Density

The minimum density of discharge, in mm/min of water, for which a sprinkler installation is designed, determined from the discharge of specified group of sprinklers, in L/min, divided by the area covered, in m^2.

3.18 Design Point

A point on a distribution pipe of a precalculated installation downstream of which pipework is sized from table and upstream of which pipework is sized by hydraulic calculation.

3.19 Detector Sprinkler

A sealed sprinkler mounted on a pressurized pipeline used to control a deluge valve.

Operation of the detector sprinkler causes loss of air pressure to open the valve.

3.20 Distribution Pipe

A pipe feeding either a range pipe directly or a single sprinkler on a non-terminal range pipe more than 300 mm long.

3.21 Distribution Pipe Spur

A distribution pipe from a main distribution pipe, to a terminal branched pipe array.

3.22 Drencher

A sprayer used to distribute water over a surface to provide protection against fire exposure.

3.23 Drop

A vertical pipe feeding a distribution or range pipe.

3.24 Dry Type Sprinkler

A sprinkler intended for installation in the upright or pendent position, designed to distribute water so that approximately 40 percent of the discharge is directed upward and 60 percent is directed downward. When installed in the upright position, this discharge will cover 3.05 m diameter circle, 3 m below the sprinkler, when the sprinkler is discharging water at the rate of 0.95 L/s.

3.25 End-Center Array

A pipe array with range pipes on both sides of distribution pipe.

3.26 End-Side Array

A pipe array with range pipes on one side only of a distribution pipe.

3.27 Exhauster

A device to exhaust the air from a dry or alternate installation to atmosphere on sprinkler operation to give more rapid operation of the alarm valve.

3.28 Fastener

A device for attaching pipe hanger components to a building structure or racking.

3.29 Foam-Water Sprinkler System

A foam-water sprinkler system is a special system pipe-connected to a source of foam concentrates and to a water supply, and equipped with appropriate discharge devices for extinguishing agent discharge and for distribution over the area to be protected. The piping system is connected to the water supply through a control valve which is usually actuated by operation of automatic detection equipment installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system, foam concentrate is injected into the water, and the resulting foam solution discharging through the discharge devices generates and distributes foam.

Upon exhaustion of the foam concentrate supply, water discharge will follow the foam and continue until shut off manually. Systems may be used for discharge of water first, followed by discharge of foam for a definite period and this followed by water until manually shut off. Existing deluge sprinkler systems that have been converted to the use of aqueous film forming foam are classed as Foam-Water Sprinkler Systems.

3.30 Foam-Water Spray System

A foam-water spray system is a special system pipe-connected to a source of foam concentrate and to a water supply, and equipped with foam-water spray nozzles for extinguishing-agent discharge (foam or water sequentially in that order or in reverse order) and distribution over the area to be protected. System-operation arrangements parallel those for foam-water sprinkler systems as described in the foregoing paragraph.

3.31 (Fully) Hydraulically Calculated

A term applied to pipework sized as specified, or an installation in which all the pipework downstream of the main installation control valve set is sized as specified in BS 5306: Part 2.

3.32 Gridded Configuration Pipe Array

A pipe array in which water flows to each sprinkler by more than one route.

3.33 Hanger

An assembly for suspending pipework from elements of building structure.

3.34 High-Rise System

A sprinkler system in which the highest sprinkler is more than 45 m above the lowest sprinkler or the sprinkler pumps whichever is the lower.

3.35 Hydraulic Alarm, Intermittent

Sounding of an hydraulic water motor alarm gong for intervals totaling less than the alarm period.

3.36 Installation (Sprinkler Installation)

Part of a sprinkler system comprising a set of installation main control valves, the associated downstream pipes and sprinklers.

3.37 Installation Alternate

An installation in which the pipework is selectively charged with either water or air according to ambient temperature conditions.

3.38 Installation, Dry (Pipe)

An installation in which the pipework is charged with air under pressure.

3.39 Installation, Pre-Action

One of two types of dry, or alternate in dry mode, installation in which the alarm valve can be opened by an independent fire detection system in the protected area.

3.40 Installation, Recycling

A pre-action installation in which the alarm valve can be opened and closed repeatedly by a heat detection system.

3.41 Installation, Wet (Pipe)

An installation in which the pipework is always charged with water.

3.42 Jockey Pump

A small pump used to replenish minor water loss, to avoid starting an automatic suction or booster pump unnecessarily.

3.43 Life Safety

A term applied to sprinkler systems forming an integral part of measures required for the protection of life.

3.44 Looped Configuration

A pipe array in which there is more than one distribution pipe route along which water may flow to a range pipe.

3.45 Low-Rise System

A sprinkler system in which the highest sprinkler is not more than 45 m above ground level or the sprinkler pumps.

3.46 Main Distribution Pipe

A pipe feeding a distribution pipe (see Fig. 1).

3.47 Mechanical Pipe Joint

A component part of pipework other than threaded tubulars, screwed fittings, lead or compound sealed spigots and socket and flanged joint, used to connect pipes and to produce a seal both against pressure and vacuum.

3.48 Multiple Control

A valve, normally held closed by a temperature-sensitive element, suitable for use in a deluge system or for the operation of a pressure switch.

3.49 Node

A point in pipework at which pressure and flow(s) are calculated; each node is a datum point for the purpose of hydraulic calculations in the installation.

3.50 Pipe Array

The pipes feeding a group of sprinklers.

Note:

Pipe arrays may be looped, gridded or branched (see definitions above).

3.51 Precalculated

A term applied to pipework sized as specified in 18.1(b) of BS 5306: Part 2 or an installation in which pipes downstream of the design point are sized as specified in 18.1 (b) of BS 5306: Part 2.

3.52 Range Pipe

A pipe feeding sprinklers directly or via arm pipes of restricted length.

3.53 Riser

A vertical pipe feeding a distribution or range pipe above.

3.54 Rosette (Sprinkler Rosette)

A plate covering the gap between the shank or body of a sprinkler projecting through a suspended ceiling, and the ceiling.

3.55 Section

That part (which may be one or more zones) of an installation on a particular floor fed by a particular riser.

3.56 Sling Rod

A rod with a sling eye or screwed ends for supporting pipe clips, rings, band hanger etc.

3.57 Sprayer

A sprinkler that gives a downward conical pattern discharge.

3.58 Sprayer, High Velocity

An open nozzle used to extinguish fires of high flashpoint liquids.

3.59 Sprayer, Medium Velocity

A sprayer of sealed or open type used to control fires of lower flashpoint liquids and gases or to cool surfaces.

3.60 Sprinkler, (Automatic)

A temperature-sensitive sealing device which opens to discharge water for fire extinguishing.

Note:

The term "automatic sprinkler" is now rarely used. The term "sprinkler" does not include "open sprinkler".

3.61 Sprinkler, Ceiling of Flush Pattern

A pendent sprinkler for fitting partly above but with the temperature-sensitive element below, the lower plane of the ceiling.

3.62 Sprinkler, Concealed

A recessed sprinkler with a cover plate that disengages when heat is applied.

3.63 Sprinkler, Conventional Pattern

A sprinkler that gives a spherical pattern of water discharge. See also:

cut-off sprinkler
detector sprinkler

3.64 Sprinkler, Dry Pendent Pattern

A unit comprising a sprinkler and a dry drop pipe unit with a valve, at the head of the pipe, held closed by device maintained in position by the sprinkler head valve.

3.65 Sprinkler, Dry Upright Pattern

A unit comprising a sprinkler and dry rise pipe unit with a valve, at the base of the pipe, held closed by a device maintained in position by the sprinkler head valve.

3.66 Sprinkler, Fusible Link

A sprinkler which opens when a component provided for the purpose melts.

3.67 Sprinkler, Glass Bulb

A sprinkler which opens when a liquid-filled glass bulb bursts.

3.68 Sprinkler, Horizontal

A sprinkler in which the nozzle directs water horizontally.

3.69 Sprinkler, Intermediate

A sprinkler installed below, and additional to the roof or ceiling sprinklers.

3.70 Sprinkler, Open

A device, otherwise like a sprinkler (automatic sprinkler), not sealed by a temperature-sensitive element.

3.71 Sprinkler, Pendent

A sprinkler in which the nozzle directs water downwards.

3.72 Sprinkler, Recessed

A sprinkler in which all or part of the heat-sensing element is above the plane of the ceiling.

3.73 Sprinkler Roof or Ceiling

A sprinkler protecting the roof or ceiling.

3.74 Sprinkler, Sidewall Pattern

A sprinkler that gives an outward half-paraboloid discharge.

3.75 Sprinkler, Spray Pattern

A sprinkler that gives a downward paraboloid pattern discharge.

3.76 Sprinkler, Upright

A sprinkler in which the nozzle directs water upwards.

3.77 Sprinkler System

The entire means of providing sprinkler protection in the premises comprising one or more sprinkler installations, the pipework to the installations and the water supply/supplies except town mains and bodies of water such as lakes or canals.

3.78 Sprinkler Yoke (Arms)

The part of a sprinkler that retains the heat-sensitive element in load-bearing contact with the sprinkler head valve.

3.79 Staggered (Sprinkler) Layout

An off-set layout with the sprinklers displaced one-half pitch along the range pipe relative to the next range or ranges.

3.80 Standard (Sprinkler) Layout

A rectilinear layout with the sprinklers aligned perpendicular to the run of the ranges.

3.81 Suction Pump

An automatic pump supplying water to a sprinkler system from a suction tank, river, lake, or canal.

3.82 Suitable for Sprinkler Use

A term applied to equipment or components accepted by the authorities as for a particular application in a sprinkler system, either by particular test or by compliance with specified general criteria.

3.83 Supply Pipe

A pipe connecting a water supply to a trunk main or the installation main control valve set(s); or a pipe supplying water to a private reservoir, suction tank or gravity tank.

3.84 Suspended Open Cell Ceiling

A ceiling of regular open cell construction through which water from sprinklers can be discharged freely.

3.85 Tail-End Alternate (Wet and Dry Pipe) Extension

A part of a wet installation that is selectively charged with water or air according to ambient temperature conditions and which is controlled by a subsidiary dry or alternate alarm valve.

3.86 Tail-End Dry Extension

A part of a wet or alternate installation that is charged permanently with air under pressure.

3.87 Terminal Main Configuration

A pipe array with only one water supply route to each range pipe.

3.88 Terminal Range Configuration

A pipe array with only one water supply route from a distribution pipe.

3.89 Toggle Support

A swivel device for securing hangers to hollow section ceilings or roofs.

3.90 Trunk Main

A pipe connecting two or more water supply pipes to the installation main control valve set(s).

3.91 User

The person responsible for or having effective control over the fire safety provision adopted in or appropriate to the premises or the building.

3.92 Zone

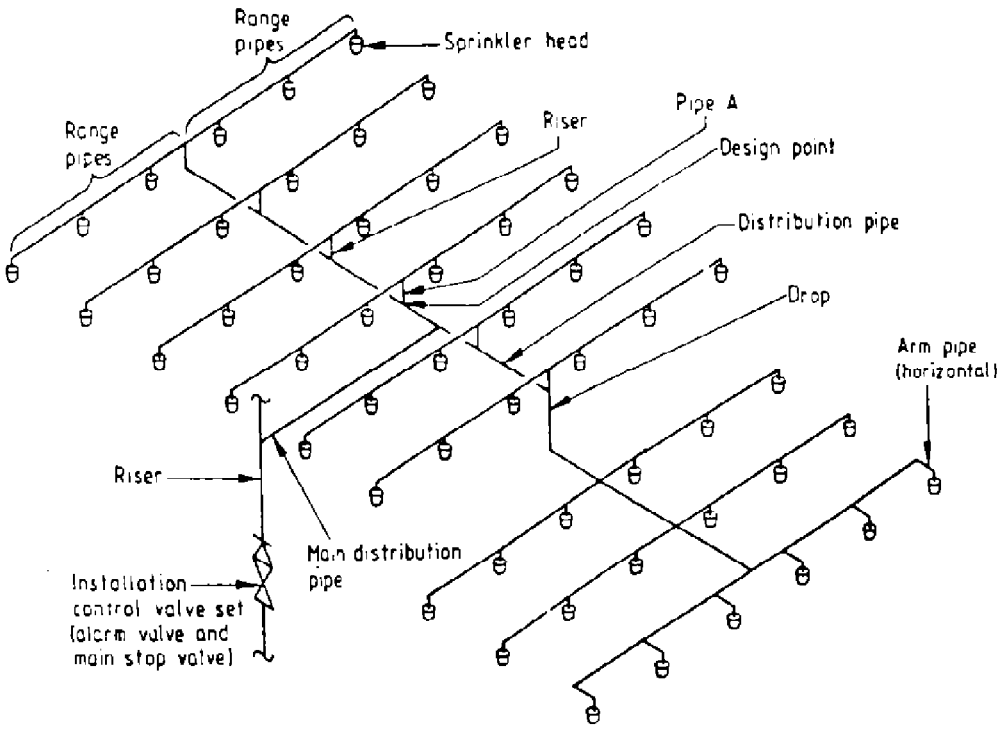
A subdivision of an installation fitted with a subsidiary stop valve or multiple control.

4. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

5. GENERAL

5.1 A sprinkler system is specialized fire protection system and requires knowledgeable and experienced design and installation. A sprinkler system consists of a water supply (or supplies) and one or more sprinkler installations, each installation consists of a set of installation main control valves and a pipe array fitted with sprinkler heads. The sprinkler heads are fitted at specified locations at the roof or ceiling, and where necessary between racks, below shelves, and in ovens or stoves. The main elements of a typical installation are shown in the Fig. 1.



MAIN ELEMENTS OF A SPRINKLER INSTALLATION
Fig. 1

The sprinklers operate at predetermined temperatures to discharge water over the affected part of the area below, the flow of water through the alarm valve initiating a fire alarm. The operating temperature is generally selected to suit ambient temperature conditions.

Only sprinklers in the vicinity of the fire, i.e., those which become sufficiently heated, operate.

In some life safety applications an authority shall require sprinkler protection only in certain designated areas and solely to maintain safe conditions for the evacuation of persons from the sprinklers protected areas. Such a system will not provide protection against a fire which starts in a non-sprinklered part of the premises and develops to some size before spreading to the sprinkled parts, and for more complete protection the sprinkler system is extended throughout the premises with only limited exceptions.

It should not be assumed that the provision of a sprinkler system entirely obviates the need for other means of fighting fires and it is important to consider the fire precautions in the premises as a whole.

Structural fire resistance, escape routes, fire alarm systems, particular hazards needing other fire protection methods, provision of hose reels and fire hydrants and portable fire extinguishers, etc., safe working and goods handling methods, management supervision and good housekeeping all need consideration.

5.2 Outline Design

5.2.1 Consideration should be given to any benefits that will be gained by changes in building design, work procedures etc., when preparing the outline design. In planning site layout and building design, particular consideration should be given to the following:

5.2.2 The occupancy hazard class and goods category which determine the water discharge density and water supply pressure and flow.

5.2.3 The siting of any town main water supply connection(s).

5.2.4 The siting of any water supply tank(s) or reservoir.

5.2.5 The siting of any pump house.

5.2.6 The maximum quantity of water available and maximum rate of supply (based on site tests at periods of maximum demand) from the supply source compared with the system requirements.

5.2.7 The location of sprinkler installation control valves, together with the access thereto, indication of their position and the disposal of drainage and water supply test water.

5.2.8 The source and means of supply of electric power, etc.

5.2.9 The protection of valve sets, pipework and sprinklers against accidental damage.

It is important to consider building design in the context of fire protection, e.g., choice of materials, support of sprinkler pipework having regard to the load imposed on structure by the weight of sprinkler pipework and the contained water, building heating, need for inbuilt drainage (which is strongly advised for computer areas) or raising of base of stacked goods above the floor where water damage may be severe, etc. When storage of goods is involved it shall be appropriate to consider the height of the building and of material stacks, and the height and type of any storage racks, which will have a considerable bearing on fire protection costs.

The design of double entry storage racks should be influenced by the need to mount sprinklers therein. Where sprinklers are fitted in racks additional rack structural members may be needed to prevent impact damage to the sprinkler head and pipework.

6. INTERACTION WITH OTHER FIRE PROTECTION MEASURES

Account shall be taken of possible interaction between sprinkler systems and other fire protection measures. Examples of possible adverse interaction between sprinkler protection and other fire protection measures are:

6.1 Water damage to an inadequately shielded fire alarm control panel in a sprinkler-protected area with consequent possible failure of the fire alarm system.

6.2 Operation or failure of smoke detectors in zones adjacent to one in which water discharge is taking place because of the water spray mist traveling into adjacent zones.

Such possible interactions need particularly careful consideration in the case of systems which are part of life safety measures.

7. BUILDINGS TO BE SPRINKLER-PROTECTED

The sprinkler system shall provide protection to all parts not specified as exceptions in 7-3 of the following:

7.1 The building under consideration.

7.2 Any building communicating directly or indirectly with the building under consideration.

7.3 Exceptions (Buildings and Parts of Buildings not Sprinkler-Protected)

7.3.1 Obligatory exceptions

Sprinkler protection shall not be provided in the following parts of a building or plant:

a) Areas, rooms, or places where the water discharged from a sprinkler may present a hazard.

7.3.2 Optional exceptions

Sprinkler-protection shall be considered for, but need not be provided in the following parts of a building or plant:

a) Stairs, spaces below stair headings (but not rooms above a stair) and lift wells. Any part not provided with sprinkler protection shall be enclosed by walls, ceilings and floors with a fire resistance of not less than 2 h, in which all doors are of not less than 1 h fire resistance, and in which all glazed areas either are of not less than 1 h fire resistance or in the case of stairs are protected by cut-off sprinklers. The area of glazing in any part not provided with sprinkler-protection shall not exceed 1.5 m^2 in each storey;

b) washrooms, toilets and WCs (but not cloakrooms);

c) rooms or compartments containing electric power distribution apparatus, such as switchgear and transformers, and used for no other purpose(s). Any part not provided with sprinkler protection shall be enclosed by walls, ceilings and floors of not less than 2 h fire resistance in which all doors are of not less than 1 h fire resistances;

d) areas containing oil or similar flammable liquids.

7.4 Communicating buildings. Sprinkler protection shall be considered for, but need not be provided in the following communicating buildings or structures:

7.4.1 A building or storey separated from the sprinklered building by walls of not less than 6 h fire resistance in which each opening is protected by two (arranged in series) fire doors or fire shutters each of not less than 2 h fire resistance.

7.4.2 Canopies of non-combustible construction, not extending beyond 2.3 m from the building wall.

Any such canopy not provided with sprinkler protection shall be fitted with cut-off sprinklers under the canopy over each opening between it and the sprinklered building. Any opening 2.5 m or less in width shall be provided with a cut-off sprinkler, positioned centrally over the opening. Openings exceeding 2.5 m in width shall be provided with cut-off sprinklers over the opening, and not more than 2.5 m apart and with a sprinkler not more than 1.25 m from each side.

7.4.3 Exterior loading docks and platforms either of non-combustible construction or with the space beneath closed off against accumulation of debris.

7.4.4 Buildings used solely as offices and/or private dwelling(s). Any part not provided with sprinkler protection shall be separated from the sprinkler protected building by a wall of not less than 6 h fire resistance in which any glazed areas are of not less than 1 h fire resistance and are provided with cut-off sprinklers, and in which all door openings are protected by either:

a) Single fire doors or single fire shutters of not less than 2 h fire resistance; or
b) fire doors of not less than 1 h fire resistance and cut-off sprinklers.

7.4.5 Buildings, storeys or rooms of non-combustible construction used mainly for wet processes.

7.4.6 Stairs, washrooms and WCs external to the sprinkler-protected building in which all openings to the sprinkler-protected building are protected by doors of not less than 1 h fire resistance.

7.4.7 Staircases, washrooms, toilets and WCs external or internal to the sprinkler-protected building which form a means of communication between the sprinklered building and a non-sprinklered building. In any such part not provided

with sprinkler protection all openings into the communicating area from the sprinklered and from the nonsprinklered building shall be protected by fire doors of not less than 1 h fire resistance.

8. CLASSIFICATION OF OCCUPANCIES

8.1 Occupancy classifications for this standard relate to sprinkler installations and their water supplies only. They are not intended to be a general classification of occupancy hazards.

8.2 Light Hazard

Occupancies or portions of other occupancies where the quantity and/or combustibility of contents is low and fires with relatively low rates of heat release are expected.

8.3 Ordinary Hazard (Group 1)

Occupancies or portions of other occupancies where combustibility is low, quantity of combustibles is moderate, stock-piles of combustibles do not exceed (2.4 m), and fires with moderate rates of heat release are expected.

8.4 Ordinary Hazard (Group 2)

Occupancies or portions of other occupancies where quantity and combustibility of contents is moderate, stockpiles do not exceed (3.7 m), and fires with moderate rate of heat release are expected.

8.5 Ordinary Hazard (Group 3)

Occupancies or portions of other occupancies where quantity and/or combustibility of contents is high, and fires of high rate of heat release are expected.

8.6 Extra Hazard Occupancies

8.6.1 Extra Hazard Occupancies or portions of other occupancies where quantity and combustibility of contents is very high, and flammable and combustible liquids, dust, lint, or other materials are present introducing the probability of rapidly developing fires with high rates of heat release.

8.6.2 Extra Hazard Occupancies involve a wide range of variables that may produce severe fires. The following shall be used to evaluate the severity of Extra Hazard Occupancies:

Extra Hazard (Group 1) includes occupancies described in 8-3 with little or no flammable or combustible liquids.

Extra Hazard (Group 2) includes occupancies described in 8-4 with moderate to substantial amounts of flammable or combustible liquids or where shielding of combustibles is extensive.

9. DESIGN

9.1 The type, size and design of each sprinkler used in the system shall be appropriate to the hazards covered by the installation.

In addition to the size limits appropriate to types given in this Standard, an installation shall not cover more than the following:

9.1.1 If protecting an explosion hazard, the containment area of the hazard or

9.1.2 If protecting a computer area, the computer area except where the installation includes a zone covering only the computer area.

9.2 Sprinkler systems shall be designed for a maximum working pressure of 1/20 MPa.

Note:

Higher design pressures shall be used when all system components are rated for pressures higher than 1/20 MPa.

10. TYPES

A sprinkler installation shall be based on one of the following main types:

10.1 Wet Pipe

10.2 Alternate (Wet and Dry Pipe)

10.3 Dry Pipe

10.4 Pre-Action

10.5 Recycling

Installations based on 10.1 and/or 10.2 above shall also include extensions of the following additional types:

10.6 Tail-End Alternate

10.7 Tail-End Dry Pipe

10.8 Deluge

Wet pipe installations are preferred. However if the temperature of the premises cannot be guaranteed to remain above freezing at all times an alternate installation should be fitted. Where only part of the premises falls below 5°C during the winter, a tail-end alternate extension should be installed in that part as an extension to the wet installation.

Where freezing or elevated temperatures are experienced either frequently or continuously a dry pipe installation should be installed, or only in small areas tail-end dry pipe extensions should be installed as extensions to the main installation.

Sprinkler installations shall incorporate deluge systems to cover small areas of flammable liquid hazards such as oil-fired boiler rooms etc.

11. WET PIPE INSTALLATIONS

11.1 Wet pipe installations shall only be installed where there is no danger at any time of the water in the pipes freezing, and where the temperature will not exceed 70°C. Anti-freeze shall not be employed as a means of preventing the water freezing in the pipes.

11.2 The member of sprinklers in an installation, section or zone (including tail-end extensions, but not including sprinklers in concealed spaces or in machines etc.) shall not exceed the following:

- Light hazard 500 per installation.
- Ordinary hazard 1000 per installation.
- High hazard 1000 per installation.

12. ALTERNATE (WET AND DRY PIPE) INSTALLATIONS

12.1 Alternate installations shall only be installed where there is an intermittent danger of the water in the pipes freezing, for example, during the winter months, and where the ambient temperature does not exceed 70°C.

12.2 Alternate installations shall not be used for the protection of high-hazard storage. Areas where freezing conditions is experienced at times when the installation is in the wet mode it can be protected by a tail-end dry or alternate system, or with dry upright or dry pendent sprinklers projecting into the low-temperature area.

12.3 The member of sprinklers, including any in tail-end extensions, shall not exceed the following:

- Light hazard 250 per installation
- Light hazard without Accelerator or exhauster 125 per installation
- Ordinary & high hazard with accelerator or exhauster 500 per installation
- Ordinary & high hazard without accelerator or exhauster 250 per installation
- Combined light and ordinary 500 per installation
- Combined light & high 250 per installation.

13. DRY PIPE INSTALLATIONS

13.1 Dry pipe installations shall only be installed where the conditions are such that a wet pipe system or alternate installation cannot be used.

13.2 The number of sprinklers shall not exceed the following:

- Light hazard with accelerator or exhauster 250 per installation
- Light hazard without accelerator or exhauster 125 per installation
- Ordinary and/or high hazard with accelerator or exhauster 500 per installation
- Ordinary and/or high hazard without accelerator or exhauster 250 per installation
- Combined light and ordinary. 500 per installation
- Combined light and high. 250 per installation

14. PRE-ACTION INSTALLATIONS

14.1 There are two types of pre-action installation as follows:

14.1.1 Type 1, which shall be installed only to prevent a premature discharge of water from pipework or sprinklers that have suffered mechanical damage; and

14.1.2 Type 2, which shall be installed only to facilitate an early discharge of water from a dry pipe or alternate installation by opening the installation main control valve, thus filling the installation pipework with water, upon operation of a fire detection system.

14.2 The number of sprinklers shall not exceed the following:

- Light hazard 500 per installation
- Ordinary hazard 1000 per installation
- High hazard 1000 per installation

15. RECYCLING INSTALLATIONS

15.1 Recycling installations shall only be installed where it is necessary for the following reasons:

15.1.1 To restrict water damage after a fire is extinguished.

15.1.2 To avoid closure of the main installation stop valve if modifications are made to the installation pipework or if sprinkler heads are to be replaced.

15.1.3 To prevent water damage caused by accidental mechanical damage of the installation pipework or sprinklers.

15.1.4 The heat detectors and control equipment shall be suitable for use in recycling pre-action sprinkler installations.

15.1.5 The number of sprinklers shall not exceed 1000 per installation.

16. TAIL-END ALTERNATE PIPE AND TAIL-END DRY PIPE EXTENSIONS

16.1 Tail-end alternate extensions shall be installed only in comparatively small areas where there is a possible frost danger in an otherwise adequately heated building as extensions to wet pipe installations. They shall comply with the appropriate requirements of Clause 12.

16.2 Tail-end dry extensions shall be installed only as the following:

16.3 Extensions to wet or alternate installations in high-temperature ovens or stoves; or

16.4 Extensions to wet, dry or alternate installations in buildings where freezing conditions may occur and with an air/gas pressure not less than the air/gas pressure between the main installation control valve and the tail-end valve.

They shall comply with the appropriate requirements of clause 13.

16.5 The number of sprinklers on any tail-end extension shall not exceed 100. Where more than two tail-end extensions are controlled by one installation control valve set, the total number of sprinklers in the tail-end extensions shall not exceed 250.

17. DELUGE INSTALLATIONS

17.1 Deluge installations shall be installed only where it is necessary to apply water over an entire area in which a fire may originate.

18. WATER SUPPLIES

18.1 Reliability

18.1.1 All practical steps shall be taken to ensure the continuity and reliability of water supplies.

18.1.2 The flow from town mains to the sprinkler system shall be reduced by fire brigade operations.

18.1.3 Water supplies should preferably be under the control of the user, or guaranteed by the organization having control. The pressure and flow capacity of town mains are not guaranteed.

18.1.4 Warning

Where an installation has a town main supply a reduction in pressure will have adverse consequences. Stored water supplies provide more security in this respect.

18.1.5 Frost protection

The installation main control valve set and the feed pipe shall be maintained at a minimum temperature of 4°C.

18.2 Quality

Water supplies for sprinkler installations shall be free from suspended fibrous or other matter which accumulates in the system pipework.

Salt or brackish water shall not be retained in sprinkler installation pipework.

Where there is no suitable fresh water source available a salt or brackish water supply shall be used provided the installation is normally charged with fresh water.

18.3 Ring Mains

Where sprinkler systems are fed by a ring main supply pipe arrangement on the premises, any isolating valves on the ring main shall be of the interlocking key type. Isolating valves positioned at various suitable points on a ring main enable the supply to be maintained to the maximum possible extent in the event of fracture or other need to close down part of the ring main.

18.4 Housing of Equipment for Water Supplies

Equipment, such as pumps, pressure tanks and gravity tanks, shall not be housed in buildings or sections of premises in which there are hazardous processes or explosion hazards.

18.5 Types of Water Supply

18.5.1 Low rise systems selection of suitable supplies:

18.5.2 Systems for light- and ordinary-hazard occupancies shall be provided with the following:

a) A single supply complying with 18.5.5; or
b) a superior supply complying with 18.5.6; or
c) duplicate supplies complying with 18.5.7.

Wherever practical a superior supply or duplicate supplies should be provided.

18.5.3 Systems for high-hazard occupancies shall be provided with the following:

a) A superior supply complying with 18.6.6; or
b) duplicate supplies complying with 18.6.7.

18.5.4 Provision of fire brigade inlet

Systems supplied only from a pressure tank and/or a gravity tank and/or a pump suction tank shall, if possible, be fitted with a fire brigade inlet.

It is strongly emphasized that a fire brigade inlet be fitted to all systems to allow the brigade to pump water into the system using their own equipment.

The water authority will not normally allow a fire brigade inlet on systems with town main supplies, because water from the inlet could enter the town main.

18.5.5 Single supplies

A single supply shall be one of the following:

a) A town main; or
b) a single automatic suction pump, drawing water from a source; or
c) a single automatic booster pump, drawing water from a town main.

18.5.6 Superior supplies

A superior supply shall be one of the following:

a) A town main; or
b) two automatic suction pumps drawing water from a suction tank; or
c) two automatic booster pumps; or
d) an elevated private reservoir; or
e) a gravity tank; or
f) a pressure tank for light- and/or ordinary-hazard group 1 occupancies only.

18.5.7 Duplicate supplies

Duplicate supplies shall include at least one of the suitable combinations given in Table 1. The supply pipes from each source shall be joined into a common trunk main at a point as close as possible to the protected premises.

The common trunk main shall neither: traverse ground not under the control of the user; nor be under a public roadway.

The common trunk main shall serve more than one installation in a system.

18.5.8 High rise systems

The water supply for a high-rise system shall be either:

a) A gravity tank; or
b) an automatic suction pump arrangement in which each installation is served by either a separate pump or a separate stage of a multistage pump.

19. DESIGN DENSITY AND AMAO* FOR FULLY HYDRAULICALLY CALCULATED INSTALLATIONS

19.1 For fully hydraulically calculated installations the density of discharge, calculated, shall not be less than the appropriate value when all the ceiling or roof sprinklers in the room concerned, or in the AMAO, whichever is the fewer, plus any supplementary sprinklers, and/or sprayers, and/or medium-velocity sprayers, and/or high-velocity sprayers, installed below the roof or ceiling sprinklers considered to be in operation, are in operation.

The basis for full hydraulic calculation for all fire hazard classes is the specification of a minimum design density from a group of sprinklers (four in number if the number in open communication is four or more) in a specified geometric pattern. This group is the most hydraulically remote from the water supply, and is part of a larger group of sprinklers assumed to be discharging simultaneously. The larger group is the AMAO and is specified for each hazard class. The hydraulically most unfavorable AMAO is used to calculate design density.

19.2 Light Hazard

The design density and the AMAO of roof or ceiling sprinklers shall not be less than as given in Table 2.

Not more than six sprinklers shall be installed in a room, except in either a corridor where there is a single line of sprinklers or a concealed space protected.

*** Assumed maximum area of operation (see definition).**

19.3 Ordinary Hazard

The design density and AMAO of roof or ceiling sprinklers for each of the various groups shall be not less than as given in Table 2.

19.4 High Hazard

19.4.1 Process hazard

The minimum design density and AMAO shall not be less than as given in Table 2.

TABLE 1 - COMBINATIONS SUITABLE FOR DUPLICATE WATER SUPPLIES

SUPPLY SUPPLY	TOWN MAIN WITH OR WITHOUT BOOSTER PUMP	BOOSTER PUMP FROM ELEVATED PRIVATE RESERVOIR	SUCTION PUMP	GRAVITY TANK	ELEVATED PRIVATE RESERVOIR	PRESSURE TANK
PRESSURE TANK	LIGHT ORDINARY	LIGHT ORDINARY	LIGHT ORDINARY	SUITABLE ONLY WITH A THIRD SUPPLY GIVEN AS SUITABLE	LIGHT ORDINARY	SUITABLE ONLY WITH A THIRD SUPPLY GIVEN AS SUITABLE
ELEVATED PRIVATE RESERVOIR	NOT SUITABLE	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH	
GRAVITY TANK	NOT SUITABLE	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH*		
SUCTION PUMP	NOT USUALLY PERMITTED	LIGHT ORDINARY HIGH	LIGHT ORDINARY HIGH			
BOOSTER PUMP FROM ELEVATED PRIVATE RESERVOIR	NOT USUALLY PERMITTED	LIGHT ORDINARY HIGH				
TOWN MAIN WITH OR WITHOUT BOOSTER PUMP	LIGHT ORDINARY HIGH					

*** A DIVIDED TANK OR TWO SEPARATE TANKS MAY BE USED.**

TABLE 2 - MINIMUM DESIGN DENSITY AND AMAO FOR LIGHT-ORDINARY-AND HIGH-HAZARD (PROCESSES) ROOF OR CEILING SPRINKLERS

HAZARD	MINIMUM DESIGN DENSITY mm / min	AMAO m^2
LIGHT	2.25	84
ORDINARY GROUP I GROUP II GROUP III	 5 5 5	 72 144 216
HIGH (PROCESSES) TYPE I TYPE 2* TYPE 3 TYPE 4	 7.5 10.0 12.5 10.0	 260 260 260 COMPLETE DELUGE PROTECTION FOR EACH BUILDING

*** Type 2 category III in Table 4 of BS 5306 Pt 2 for process of high hazards includes:**

- **Flammable liquids in combustible containers.**
- **Rubber goods.**
- **Wooden pallets and wooden flats (idle)**
- **Hazard of Types 1,3 and 4 in the Table 2 above are not applicable in the IPI.**

19.5 High-Piled Storage Hazards (Goods), Storage Classes S1 and S4

Where the storage height exceeds that for ordinary hazard, the design density and AMAO of roof or ceiling sprinklers shall be not less than the appropriate value given in Table 3.

Note:

Classes S1 thru S8 are the types of storage methods as given hereunder:

S1 Free standing or block stacking
S2 Post or box pallets in single rows
S3 Post or box pallets in multiple rows
S4 Open bottom post pallets
S5 Palletized rack (beam pallet racking)
S6 Solid or slatted shelves 1 m or less wide
S7 Solid or slatted shelves over 1 m and not more than 6 m wide
S8 Solid or slatted shelves over 1 m wide where intermediate sprinklers can not be installed.

TABLE 3 - MINIMUM DESIGN DENSITY AND AMAO FOR HIGH-PILED STORAGE HAZARDS (GOODS), STORAGE TYPES S1 AND S4 ROOF OR CEILING SPRINKLERS

Category I S1 only		Category II S1 only		Category III S1 and S4		Category IV S1 only		Minimum design density	AMAO	
Steak height		Steak height		Steak height		Steak height			Wet pipe, pre-action and recycling systems	Dry pipe and alternate systems
more than	not more than	more than	not more than	more than	not more than	more than	not more than			
m	m	m	m	m	m	m	m	mm / min	m^2	m^2
0	5.3	0	4.1	0	2.9	0	1.6	7.5	260	325
5.3	6.5	4.1	5.0	2.9	3.5	1.6	2.0	10.0	260	325
6.5	7.6	5.0	5.9	3.5	4.1	2.0	2.3	12.5	260	325
—	—	5.9	6.7	4.1	4.7	2.3	2.7	15.0	260	325
—	—	6.7	7.5	4.7	5.2	2.7	3.0	17.5	260	325
—	—	—	—	5.2	5.7	3.0	3.3	20.0	300	375
—	—	—	—	5.7	6.3	3.3	3.6	22.5	300	375
—	—	—	—	6.3	6.7	3.6	3.8	25.0	300	375
—	—	—	—	6.7	7.2	3.8	4.1	27.5	300	375
—	—	—	—	—	—	4.1	4.4	30.0	300	375

Note:

Class S4 includes only category III rubber types.

19.6 High-Piled Storage Hazards (Goods), Storage Classes S2 and S5

Where the storage height exceeds that for ordinary hazard, the design density and AMAO shall not be less than the appropriate value given in Table 4.

TABLE 4 - MINIMUM DESIGN DENSITY AND AMAO FOR HIGH-PILED STORAGE HAZARDS (GOODS), STORAGE TYPES S2 AND S5 ROOF OR CEILING SPRINKLERS

Category I		Category II		Category III		Category IV		Minimum design density	AMAO	
Steak height		Steak height		Steak height		Steak height			Wet pipe, pre-action and recycling systems	Dry pipe and alternate systems
more than	not more than	more than	not more than	more than	not more than	more than	not more than			
m	m	m	m	m	m	m	m	mm / min	m^2	m^2
0	4.7	0	3.4	0	2.2	—	—	7.5	260	325
4.7	5.7	3.4	4.2	2.2	2.6	1.6	2.0	10.0	260	325
5.7	6.8	4.2	5.0	2.6	3.2	2.0	2.3	12.5	260	325
—	—	5.0	5.6	3.2	3.7	2.3	2.7	15.0	260	325
—	—	5.6	6.0	3.7	4.1	2.7	3.0	17.5	260	325
—	—	—	—	4.1	4.4	3.0	3.3	20.0	300	375
—	—	—	—	4.4	5.3	3.3	3.8	25.0	300	375
—	—	—	—	5.3	6.0	3.8	4.4	30.0	300	375

19.7 High-Piled Storage Hazards (Goods), Storage Classes S3, S6, S7 and S8

For goods of classes S3 and S6, stored to heights above 5.7 m and for goods of classes S7 and S8 the design density and AMAO shall not be less than as given in Table 5.

TABLE 5 - MINIMUM DESIGN DENSITY AND AMAO FOR HIGH-PILED STORAGE HAZARDS (GOODS), STORAGE TYPES S3, S6, S7 AND S8 ROOF OR CEILING SPRINKLERS

Category I		Category II		Category III		Category IV		Minimum design density	AMAO	
Steak height		Steak height		Steak height		Steak height			Wet pipe, pre-action and recycling systems S3, S6, S7, S8	Dry pipe and alternate systems S3 and S8 only
more than	not more than	more than	not more than	more than	not more than	more than	not more than			
m	m	m	m	m	m	m	m	mm / min	m^2	m^2
0	4.7	0	3.4	0	2.2	0	1.6	7.5	260	325
4.7	5.7	3.4	4.2	2.2	2.6	1.6	2.0	10.0	260	325
—	—	4.2	5.0	2.6	3.2	2.0	2.3	12.5	260	325
—	—	—	—	—	—	2.3	2.7	15.0	260	325
—	—	—	—	—	—	2.7	3.0	17.5	260	325

19.8 High-piled storage hazards (goods), roof or ceiling protection where intermediate sprinklers are fitted in racks or under shelves.

19.8.1 Where roof or ceiling sprinklers are more than 3 m above the top of the goods the roof or ceiling sprinklers shall have a design density of not less than 7.5 mm min and an AMAO of not less than 260 m^2 and intermediate sprinklers shall be provided at each tier, including the top tier, of storage.

19.8.2 Where roof or ceiling sprinklers are not more than 3 m above the top of the goods the roof or ceiling sprinklers shall have a design density and an AMAO not less than as given in Table 6 and intermediate sprinklers shall be provided at each tier, except the top tier, or storage.

TABLE 6 - MINIMUM DESIGN DENSITY AND AMAO FOR HIGH-PILED STORAGE HAZARDS (GOODS), TOP TIER PROTECTION BY ROOF OR CEILING SPRINKLERS ONLY

Category I	Category II	Category III		Category IV		Minimum design density	AMAO Wet pipe pre-action and recycling systems
Steak height not more than	Steak height not more than	Steak height		Steak height			
		more than	not more than	more than	not more than		
m	m	m	m	m	m	mm / min	m^2
4.7	3.5	—	2.2	—	1.6	7.5	260
—	—	2.2	2.6	1.6	2.0	10.0	260
—	—	2.6	3.2	2.0	2.3	12.5	260
—	—	3.2	3.5	—	—	15.0	260

20. WATER SUPPLY PRESSURE-FLOW CHARACTERISTICS AND VELOCITY

20.1 General

20.1.1 Application

For the purposes of this clause requirements applicable to wet pipe installations also apply to pre-action and recycling installations and requirements applicable to alternate installations apply also to dry pipe, tail-end dry pipe and tail-end alternate installations.

20.1.2 High hazards, extra sprinklers

Where additional sprinklers are installed because of obstructions within racks or to protect columns within storage areas, the water supply for the extra sprinklers within the AMAO shall be added to that for the normal installation.

20.2 Precalculated Pipe Size Installations

20.2.1 Light hazard

The water supply running pressure at the "C" gage shall be not less than 2.2 bar plus the static pressure equivalent of the height of the highest sprinkler in the installation above the "C" gage when a water flow rate of 225 L/min is established through the drain and test valve.

20.2.2 Ordinary hazard

20.2.2.1 The water supply running pressure at each section control in a high-rise installation, or at the "C" gage in a low-rise installation, shall not be less than that specified in Table 7 when the higher and lower water flow rates are established through the drain and test valve.

20.2.2.2 High-rise installations

Each installation rise pipe shall be provided with a jockey pump to maintain the static pressure at any check or alarm valve at not less than 1.25 times the static head difference between the valve and the highest sprinkler in the installation. The jockey pump shall not be so large as to prevent the operation of suction or booster pumps when a single sprinkler operates.

TABLE 7 - PRESSURE AND FLOW REQUIREMENTS FOR ORDINARY-HAZARD INSTALLATIONS

Hazard group	Lower flow rate		Higher flow rate	
	Pressure at "C" gage or section stop valve bar	Flow rate through installation test valve L/min	Pressure at "C" gage or section stop valve bar	Flow rate through installation test valve L/min
I	1.0+S*	375	0.7+S*	540
II	1.4+S*	725	1.0+S*	1000
III	1.7+S*	1100	1.4+S*	1350

*** S is the static pressure difference between the 'C' gage and the highest sprinkler in the installation.**

20.2.3 High hazard

20.2.3.1 The water supply running pressure at the control valve 'C' gage shall not be less than either:

a) Where the AMAO is not larger than the area protected $P_r + P_f + P_s$; or

b) where the AMAO is larger than the area protected $P_{red} + P_f + P_s$;

Where:

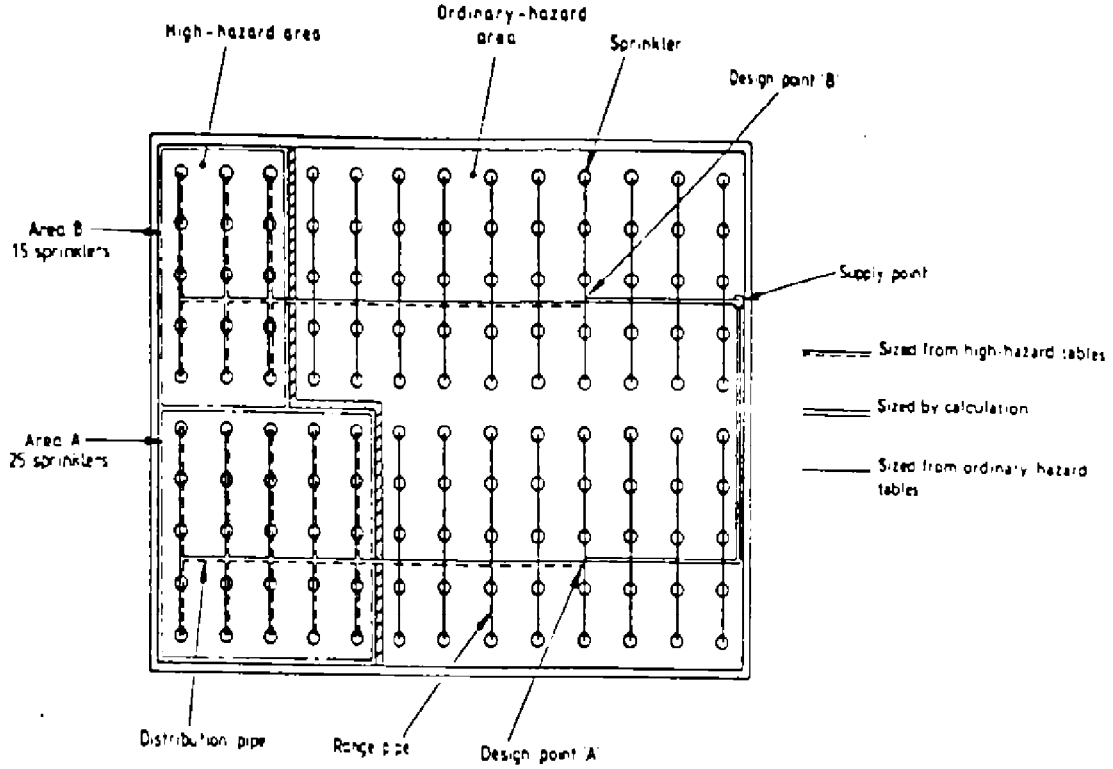
$\mathbf{P_{red}}$ is the running pressure specified in Tables 8, 9, 10 or 11 as appropriate at a flow rate equal to area protected times the flow rate specified in the AMAO table (in bar);

$\mathbf{P_r}$ is the running pressure at the design point and flow rate specified in Tables 8, 9, 10 or 11 as appropriate (in bar);

$\mathbf{P_f}$ is the calculated pipe friction loss between the control valve "C" gage and the most hydraulically remote design point (in bar);

$\mathbf{P_s}$ is the static pressure difference between the highest sprinkler downstream of the design point and the control valve "C" gage (in bar).

c) where AMAO is fed by more than one distribution pipe the pipe friction loss shall be calculated on the basis that the flow rates in the distribution pipes are in proportion to the fraction of the design area fed by each distribution pipe (see Fig. 2).



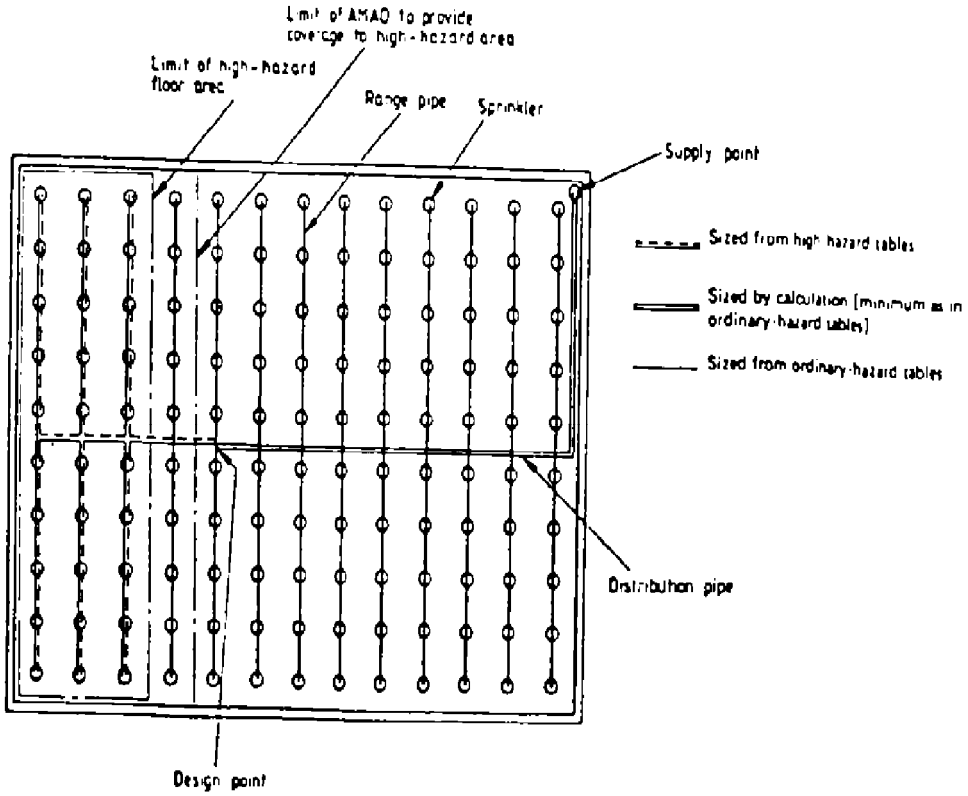
AMAO FED BY TWO DISTRIBUTION PIPES
Fig. 2

20.2.4 Mixed high / ordinary hazard

Where the area of the high-hazard protection is less than the AMAO but there is an adjacent area of ordinary hazard in the same room (i.e., an area in which sprinklers are liable to operate simultaneously), the high-hazard area flow rate required shall be reduced by the ratio of the actual area to the AMAO (see Clause 19) and to this flow rate shall be added the flow rate for the ordinary hazard area taken as 5.0 X the excess of the specified high-hazard AMAO over the actual high-hazard area (L/min).

The water supply running pressure shall be based on the level of the highest sprinkler in the high-hazard area and shall be not less than that specified in 20.2.3.1.

The ordinary-hazard portion of the installation shall be supplied as specified in 20.2.2, and the high-hazard distribution pipe feeding both high-and ordinary-hazard sprinklers shall be of bore not less than as specified in the ordinary-hazard pipe tables. (See Fig. 2a covering Clauses 20.2.3 and 20.2.4.)



AMAO COVERING HIGH AND ORDINARY HAZARD
Fig. 2a

The following Tables cover Clause 20.2.3:

TABLE 8 - PRESSURE AND FLOW REQUIREMENTS FOR HIGH-HAZARD INSTALLATION, WITH 15 mm SPRINKLERS (PRECALCULATED) AND PIPE SIZES FROM TABLES 12 AND 14

Minimum design density mm /min	Flow rate through installation test valve		Running pressure at the design point at the level of the highest sprinkler in the high-hazard area						
	Wet pipe, pre-action, and recycling installations L/min	Alternate and dry (including tail and) installations L/min	Floor area per sprinkler (m^2)						
			6 bar	7 bar	8 bar	9 bar	10* bar	11* bar	12* bar
7.5	2300	2875	—	—	1.80	2.25	2.80	3.35	3.95
10.0	3050	3825	1.80	2.40	3.15	3.90	4.80	5.75	6.80
12.5	3800	4750	2.70	3.65	4.75	6.00	7.30	—	—
15.0	4550	5700	3.80	5.20	6.75	—	—	—	—

TABLE 9 - PRESSURE AND FLOW REQUIREMENTS FOR HIGH-HAZARD INSTALLATIONS, WITH 15 mm SPRINKLERS (PRECALCULATED) AND PIPE SIZES FROM TABLES 12 AND 15

Minimum design density mm /min	Flow rate through installation test valve		Running pressure at the design point at the level of the highest sprinkler in the high-hazard area						
	Wet pipe, pre-action, and recycling installations L/min	Alternate and dry (including tail and) installations L/min	Floor area per sprinkler (m^2)						
			6 bar	7 bar	8 bar	9 bar	10* bar	11* bar	12* bar
7.5	2300	2875	—	—	1.35	1.75	2.15	2.65	3.15
10.0	3050	3825	1.30	1.80	2.35	3.00	3.75	4.55	5.45
12.5	3800	4750	2.00	2.75	3.60	4.60	5.70	7.00	8.35
15.0	4550	5700	2.80	3.85	5.10	6.50	—	—	—

TABLE 10 - PRESSURE AND FLOW REQUIREMENTS FOR HIGH-HAZARD INSTALLATIONS, WITH 15 mm SPRINKLERS (PRECALCULATED) AND PIPE SIZES FROM TABLE 12

Minimum design density mm /min	Flow rate through installation test valve		Running pressure at the design point at the level of the highest sprinkler in the high-hazard area						
	Wet pipe, pre-action, and recycling installations L/min	Alternate and dry (including tail and) installations L/min	Floor area per sprinkler (m^2)						
			6 bar	7 bar	8 bar	9 bar	10* bar	11* bar	12* bar
7.5	2300	2875	—	—	0.70	0.90	1.10	1.35	1.60
10.0	3050	3825	0.70	0.95	1.25	1.60	1.95	2.35	2.80
12.5	3800	4750	1.10	1.50	1.95	2.45	3.05	3.70	4.35
15.0	4550	5700	1.60	2.15	2.80	3.55	4.35	5.25	6.25
17.5	4850	6075	2.15	2.90	3.80	4.80	5.90	7.15	—
20.0	6400	8000	2.80	3.80	5.00	6.30	7.75	—	—
22.5	7200	9000	3.50	4.80	6.30	7.95	—	—	—
25.0	8000	10000	4.35	5.90	7.75	—	—	—	—
27.5	8800	11000	5.25	7.15	—	—	—	—	—
30.0	9650	12100	6.20	—	—	—	—	—	—

*** See 22.1.3 for restrictions on use of these spacings.**

TABLE 11 - PRESSURE AND FLOW REQUIREMENTS FOR HIGH-HAZARD INSTALLATIONS, WITH 20 mm SPRINKLERS (PRECALCULATED)

AND PIPE SIZES FROM TABLE 13

Minimum design density mm /min	Flow rate through installation test valve		Running pressure at the design point at the level of the highest sprinkler in the high-hazard area						
	Wet pipe, pre-action, and recycling installations L/min	Alternate and dry (including tail and) installations L/min	Floor area per sprinkler (m^2)						
			6 bar	7 bar	8 bar	9 bar	10* bar	11* bar	12* bar
7.5	2300	2875	—	—	—	—	—	0.80	0.95
10.0	3050	3825	—	—	—	0.95	1.15	1.40	1.65
12.5	3800	4750	—	0.90	1.15	1.45	1.80	2.15	2.55
15.0	4550	5700	0.95	1.25	1.65	2.10	2.55	3.10	3.65
17.5	4850	6075	1.25	1.70	2.25	2.80	3.45	4.20	4.95
20.0	6400	8000	1.65	2.25	2.95	3.70	4.60	5.55	6.55
22.5	7200	9000	2.05	2.85	3.70	4.70	5.75	6.95	—
25.0	8000	10000	2.55	3.50	4.55	5.75	7.10	—	—
27.5	8800	11000	3.05	4.20	5.50	6.90	—	—	—
30.0	9650	12100	3.60	4.95	6.50	—	—	—	—

*** See 22.1.3 for restrictions on use of these spacings.**

The following tables give pipe sizes referred to in Tables 8, 9, 10 and 11:

TABLE 12 - RANGE PIPE NOMINAL SIZES FOR VARIOUS PIPE LAYOUTS, FOR HIGH-HAZARD INSTALLATIONS WITH SPRINKLERS OF 15 mm NOMINAL SIZE AND PRESSURE-FLOW CHARACTERISTICS AS GIVEN IN TABLE 8 OR TABLE 9

Range pipe layout	Pipe nominal size mm	Maximum number of sprinklers to be fed by pipe of size listed
(a) Ranges at remote end of each distribution pipe spur		
(i) Two end-side, last two ranges	25	1
	32	2
(ii) Two end-side, last three ranges	25	2
	32	3
(iii) All other layouts, last range	25	2
	32	3
	40	4
(b) All other ranges	25	3
	32	4

TABLE 13 - RANGE PIPE NOMINAL SIZES FOR VARIOUS PIPE LAYOUTS, IN HIGH-HAZARD INSTALLATIONS WITH SPRINKLERS OF 15 mm NOMINAL SIZE AND PRESSURE-FLOW CHARACTERISTICS AS GIVEN IN TABLE 10, OR OF 20 mm NOMINAL SIZE AND PRESSURE-FLOW CHARACTERISTICS AS GIVEN IN TABLE 11

Range pipe layout	Pipe nominal size mm	Maximum number of sprinklers to be fed by pipe of size listed
(a) End-side arrangements		
(1) Last three ranges	40	1
	50	3
	65	6
(2) Other ranges	32	1
	40	2
	50	4
	65	6
(b) End-center arrangements		
(1) Two end-center layout		
(i) Last three ranges	32	1
	40	2
(ii) Other ranges	32	2 (32 mm feed to each)
(2) Three and four end-center layouts, all ranges	32	1
	40	2
	50	4

TABLE 14 - DISTRIBUTION PIPE NOMINAL SIZES FEEDING VARIOUS NUMBERS OF SPRINKLERS DOWNSTREAM OF THE DESIGN POINT, IN HIGH-HAZARD INSTALLATIONS WITH SPRINKLERS OF 15 mm NOMINAL SIZE AND PRESSURE FLOW CHARACTERISTICS AS GIVEN IN TABLE 8

Distribution pipe nominal size mm	Maximum number of sprinklers to be fed by pipe of size listed
32	2
40	4
50	8
65	12
80	18
100	48*

*** This does not preclude the use of 100 mm nominal size pipe between the design point and the installation main control valves if it complies with the hydraulic calculation requirements.**

TABLE 15 - DISTRIBUTION PIPE NOMINAL SIZES FEEDING VARIOUS NUMBERS OF SPRINKLERS DOWNSTREAM OF THE DESIGN POINT IN HIGH-HAZARD INSTALLATIONS WITH SPRINKLERS OF 15 mm NOMINAL SIZE AND PRESSURE FLOW CHARACTERISTICS AS GIVEN IN TABLE 9 OR TABLE 10 OR SPRINKLERS OF 20 mm NOMINAL SIZE AND PRESSURE-FLOW CHARACTERISTICS AS GIVEN I N TABLE 11

Range pipe layout	Distribution pipe nominal size mm	Maximum number of sprinklers to be fed by pipe of size listed
Four end-side	65	8
All other layouts	50	4
	65	8
	80	12
	100	16
	150	48*
* This does not preclude the use of 150 mm nominal size pipe between the design point and the installation main control valves if it complies with hydraulic calculation requirements		

20.2.5 Fully hydraulically calculated pipe arrays

The requirements of this clause apply to pipe arrays sized by full hydraulic calculation.

Any pipe layout shall be used subject to the sprinkler spacing and location requirements of this clause and Clause 22.

20.2.5.1 Minimum pipe sizes

The nominal bore of main and other distribution pipes, and range pipes shall not be less than as follows:

a) In a light-hazard installation; 20 mm (steel), or 22 mm (copper), or as given in Table 17 for single sprinklers

b) in an ordinary or high-hazard installation. 25 mm

20.2.5.2 Maximum range pipe size

The nominal bore of range pipes shall not be more than 65 mm, except where individual sprinklers are connected to pipes exceeding 65 mm nominal bore when the arrangement shall comply with 24.1.2. of BS 5306/Part 2.

20.2.6 Installation pipe work

All pipework downstream of a main distribution and range pipes, shall be designed in accordance with the relevant requirements of 20.2.

Range pipe sizes and the maximum number of sprinklers fed by each size of pipe in the range shall be neither more nor less than as specified hereunder:

a) Light hazard; Table 16
b) ordinary hazard; Table 17
c) high hazard. Table 12

TABLE 16 - LIGHT-HAZARD RANGE PIPE AND TERMINAL DISTRIBUTION PIPE SIZES

pipe material	Nominal size mm	Maximum length* m	Maximum number of sprinklers allowed on pipe of size stated
Copper	15	1°	1
	22	8	1
	28	N/A	3¤
Steel	20	8	1
	25	N/A	3¤

* Including allowance for changes of direction
° No elbows fitted: 500 mm if one elbow fitted.
¤ The limit of three sprinklers does not preclude the use of 25 mm nominal bore steel or 28 mm copper pipe between the 2/3 sprinkler design point and the installation control valves if hydraulic calculation shows this to be possible, nor does it follow that 25 mm steel or 22 mm copper pipe may be used between the 3rd and 4th sprinklers where the two sprinkler point is the design point.

TABLE 17 - RANGE PIPE NOMINAL SIZES FOR VARIOUS PIPE LAYOUTS IN ORDINARY-HAZARD INSTALLATION

Range pipe layout	pipe nominal size mm	Maximum number of sprinklers to be fed by pipe of size listed
(a) Ranges at remote end of each distribution pipe spur		
(1) last two ranges in two end-side layout	25	1
	32	2
(2) last three ranges in three end-side layout	25	2
	32	3
(3) last range in all other layouts	25	2
	32	3
	40	4
	50	9
(b) All other ranges	25	3
	32	4
	40	6
	50	9

Note:

Table 12 is shown under Clause 20.2.4.

20.2.7 Fully hydraulically calculated pipe size installation

20.2.7.1 The water supply running pressure at the "C" gage shall be not less than the value calculated by the method of 20.2.

20.2.7.2 Velocity

The equilibrium water velocity shall not exceed 6 m/s at any valve or flow monitoring device, or 10 m/s at any other point in the system for the stabilized flow condition at the demand point involving an AMAO or, where the system includes intermediate sprinklers, the total number of sprinklers assumed to be in simultaneous operation.

20.2.8 Calculation of pipework losses

20.2.8.1 Static pressure difference

The static pressure difference between two interconnecting points in a system shall be calculated from:

Static pressure difference, p = 0.1 h (bar)

Where:

h is the vertical distance between the points, (in m).

20.2.8.2 Pipe friction loss

Frictional pressure loss in pipes shall be calculated from the Hazen-Williams formula:

$$P = \frac{6.05 \times 10^5}{C^{1.85} \times d^{4.87}} \times L \times Q^{1.85}$$

Where:

p = loss of pressure per meter length of pipe (in bar);
Q = flow rate through pipe (in L/min);
d = mean bore of pipe (in mm);
C = a constant for the type and condition of the pipe (see below);
L = equivalent length of pipe and fittings (in m).

The following valves of C shall be used in sprinkler installation and town main calculations:

PIPE TYPE	C
Cast iron	100
Ductile iron	110
Mild steel	120
Galvanized steel	120
Spun cement	130
Copper	140
Unplasticized PVC	140
Asbestos cement	140

Note:

For equivalent length of fittings and valves see Table 37 of B.S. 5306, Part 2.

TABLE 18 - PRESSURE LOSS PER UNIT LENGTH OF PIPE FOR DESIGN FLOW RATES IN ORDINARY-HAZARD INSTALLATION

Pipe nominal bore mm	Pressure loss per unit length mbar/m
65	35
80	16
100	4.4
150	0.65
200	0.16

Notes:

1) The equivalent length of an elbow, bend or tee where the water is turned through an angle shall be taken as 3 m when using the Table or clause 18 data of BS 5306, Part 3.

2) Where heavy grade steel pipework is used calculate the pressure loss from the data in Clause 18 data using a flow rate of 1000 L/min.

21. WATER STORAGE CAPACITY

21.1 Application

For the purposes of this clause requirements applicable to wet pipe installations apply also to pre-action and recycling installations, and requirements applicable to alternate installations apply also to dry pipe, tail-end dry pipe and tail-end alternate installations.

Note:

Water storage capacities are given in m^3 and refilling rates in L/min, and that the factors used for calculation take account of this.

21.2 Source of Water

21.2.1 An appropriate source of water shall be provided as specified in Table 19.

TABLE 19 - WATER SOURCE AND DESIGN CAPACITY

Source of water	Pipework design method	Hazard class	Supply type	Design capacity m^3
Town main reservoir(s)	Either°	Light	Any	1000
Private elevated reservoir, ¤ or virtually unrestricted supply (such as river, lake or canal)	Either°	Light	Any	500
Town main reservoir or private elevated reservoirs or virtually unrestricted supply (such as river, lake or canal)	Either°	Ordinary, all groups	Any	1000
	Either*	High¤	Superior or duplicate	As specified in table 22*
Pump suction tank not dependent on inflow (Type A or B) or gravity tank	Precalculated	Light	Any	As specified in table 20
		Ordinary, all groups	Any	As specified in table 21
		High¤	Superior or duplicate	As specified in table 22
	Fully calculated	Light	Any	As specified in table 23
		Ordinary, all groups	Any	
		High	Superior or duplicate	
Pump suction tank dependent on inflow (Type C)	Precalculated	Light	Any	As specified in table 24
		Ordinary, all groups	Any	
		High	Superior or duplicate	
Pressure tank	Precalculated	Light	Superior or duplicate	7
		Ordinary, groups I	Superior	23
		Ordinary, all groups	Duplicate	15
	Fully calculated	Light	Superior or duplicate	As specified in table 23
		Ordinary, groups I	Superior or duplicate	
		Ordinary, groups II, III	Duplicate	

°i.e. precalculated or fully calculated.

¤ The capacities specified apply to private elevated reservoirs supplying the sprinkler system and other services.

* In high-hazard, precalculated installations where the area of high hazard is less than the AMAO the design capacity shall be not less than

Capacity given in column $5 \times \frac{\text{actual area of high hazard}}{\text{AMAO}}$

Plus, if there is any area of ordinary hazard in the same room
0.45 [AMAO (m^2) - actual area of high hazard (m^2)] m^3, or the design capacity appropriate to the ordinary hazard in the tables, whichever is the greater.

21.2.2 Refilling rate for suction tanks not dependent on inflow

The water source shall provide a refilling rate, f, of not less than 75 L/min for each single tank or each section of duplicate tank.

21.3 Minimum Capacity

21.3.1 Town main reservoirs

The capacity shall not be less than the appropriate design capacity, V, specified in Table 20.

21.3.2 Private elevated reservoirs and virtually unrestricted supplies

The capacity shall not be less than the appropriate design capacity, V, specified in Table 19.

21.3.3 Pump suction tanks dependent on inflow

The effective capacity shall not be less than the appropriate design capacity, V, specified in Table 19.

21.3.4 Pump suction tanks not dependent on inflow

21.3.4.1 Single tank

The effective capacity shall not be less than the following:

a) If V/f is less than 1, the appropriate design capacity, V, specified in Table 19; or
b) if V/f is not less than 1, 1.33 V or (2V - f) whichever is the less.

21.3.4.2 Duplicate tanks

The effective capacity of each tank shall not be less than the following:

a) If V/f is less than 0.7, the appropriate design capacity,V, specified in Table 19; or
b) if V/f is not less than 0.7, 1.33 V or (2V - f/0.7) whichever is the less.

21.3.5 Gravity tanks

The capacity shall not be less than the following:

a) for high-rise systems, 2V; or
b) for low-rise systems, either:

1) If V/f is less than 0.36, the appropriate design capacity, V, specified in Table 19; or

2) if V/f is not less than 0.36, (2V - 0.36f). Where the capacity exceeds the specified minimum a separate outlet pipe above the level corresponding to the specified minimum capacity may be used to supply water for other uses.

The following tables are referred to in column 5 of Table 19.

TABLE 20 - DESIGN CAPACITY, WHERE TANK IS NOT DEPENDENT ON INFLOW, FOR LIGHT-HAZARD PRECALCULATED

HEIGHT OF HIGHEST SPRINKLER ABOVE LOWEST SPRINKLER NOT EXCEEDING m	DESIGN CAPACITY m^3
15	9
30	10
45	11

TABLE 21 - DESIGN CAPACITY, WHERE TANK IS NOT DEPENDENT ON INFLOW, FOR ORDINARY-HAZARD PRECALCULATED INSULATIONS

Group	Height of highest sprinkler above lowest sprinkler not exceeding m	Design capacity m
I	15	55
	30	70
	45	80
II	15	105
	30	125
	45	140
III	15	135
	30	160
	45	185

TABLE 22 - DESIGN CAPACITY, WHERE TANK IS NOT DEPENDENT ON INFLOW, FOR LIGHT-HAZARD PRECALCULATED INSTALLATIONS

Design density mm/min	Design capacity	
	All systems except alternate and dry systems for high-hazard risks m^3	Alternate and dry systems for high-hazard risks m^3
7.5	225	285
10.0	275	345
12.5	350	440
15.0	425	535
17.5	450	565
20.0	575	720
22.5	650	815
25.0	725	910
27.5	800	1000
30.0	875	1095

TABLE 23 - DESIGN CAPACITY, WHERE TANK IS NOT DEPENDENT ON INFLOW, FOR FULLY HYDRAULICALLY CALCULATED INSTALLATIONS

Hazard class	Design capacity m^3
Light Ordinary High	0.03 Qmax. 0.06 Qmax. 0.09 Qmax.
Qmax. expressed in L/min	

Note:

Qmax. is the maximum flow demand specified in the maximum flow demand and shall be taken as the flow Qmax., at the point of intersection of the pressure flow demand characteristic of the installation and the water level "X" or in the tank full condition whichever gives the higher value.

TABLE 24 - DESIGN CAPACITY, WHERE TANK IS DEPENDENT ON INFLOW

Hazard class	Design capacity m^3
Light	2.5 or, as given in table 20 or 23 less $0.03f$, whichever is the greater
Ordinary, Group I	25 or, as given in table 21 or 23 less $0.06f$, whichever is the greater
Ordinary, Group II	50 or, as given in table 20 or 23 less $0.03f$, whichever is the greater
Ordinary, Group III	75 or, as given in table 20 or 23 less $0.03f$, whichever is the greater
High	2/3 of the value given in table 22 or 23 or, the value given in table 22 or 23 less $0.09f$, whichever is the greater

Note:

Requirements for the town main supplying the inflow are given as follows:

Town main as supply to pump suction tank dependent upon inflow. Where town main forms the supply to a tank (type C) dependent upon inflow the connection shall be reserved solely for the tank inflow and shall be provided with a bypass line with a dedicated direct reading flow meter suitable for sprinkler service. The flow meter and pipework shall be protected from freezing.

22. SPRINKLER SPACING, ARRANGEMENT AND LOCATION

22.1 Maximum Spacing Between Sprinklers and Maximum Area Protected Per Sprinkler

22.1.1 All measurements of distance between sprinklers or of areas covered by groups of individual sprinklers shall be taken in the horizontal plane.

22.1.2 Sprinklers shall be installed upright or pendent as recommended by the manufacturer, with the deflector parallel to the slope of the roof, ceiling or pitch line of stairs.

Sprinklers are therefore orientated upright or pendent relative not to the horizontal plane but to the roof ceiling or stair-case.

22.1.3 Sprinklers installed under roofs, ceilings and platforms

22.1.3.1 A line of sprinklers shall be fitted at the apex (and any sub-apex formed by a wall or partition) if:

a) The slope of the ceiling or roof is greater than 1 in 3 (i.e., is greater than 18/ ½° to the horizontal); and
b) the ranges run parallel to the roof ridge, i.e., the sprinklers are not valley fed, with the axis of the sprinkler positioned vertically;

Unless there is a row of sprinklers not more than 750 mm distant radially from the apex or sub-apex.

22.1.3.2 Where sprinklers are installed under roofs, ceilings, platforms or similar planar surfaces, the area covered by a sprinkler and the distance between adjacent sprinklers shall be not more than as given in Table 25, for non-sidewall sprinklers, or Table 26 for sidewall sprinklers, or Table 26 and Clause 22.1.3.3 for combinations of sidewall and non-sidewall sprinklers.

22.1.3.3 Where both sidewall and ceiling sprinklers are used the ceiling sprinklers shall be installed in standard layout. The layout shall be staggered relative to the sidewall sprinklers which shall be directly opposite the sprinklers on opposite walls.

The boundary of the sidewall sprinkler coverage shall be taken as not more than 3.7 m from, and parallel to, the walls against which the sidewall sprinklers are mounted. The space between the sidewall sprinkler boundaries parallel to the opposite walls is to be protected by the ceiling sprinklers in standard layout (see Table 25).

TABLE 25 - MAXIMUM COVERAGE AND MAXIMUM SPACING FOR NON-SIDEWALL SPRINKLERS

Hazard class	Maximum area coverage per sprinkler S × D in figure 3 m^2	Maximum distance between sprinklers			
		Spacing pattern see figure 3			
		Standard layout		Staggered layout	
		Along range "S" in figure 3 m	Between ranges "D" in figure 3 m	Along range "S" in figure 3 m	Between ranges "D" in figure 3 m
Light	21, see note 1	4.6, see note 1	4.6, see note 1	—	—
Ordinary	12, see note 2	4.0, see note 2	4.0, see note 2	4.6, see note 2	4.0, see note 2
High	9, see note 3	3.7	3.7	—	—

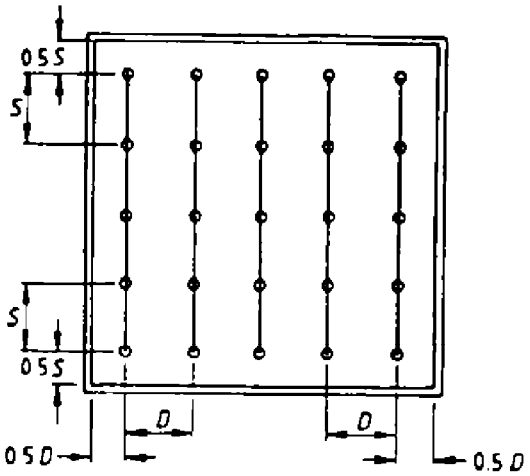
Notes:

1) In attics, basements, boiler rooms, kitchens, laundries, storage areas and workrooms the maximum area coverage shall be 9.0 m^2, and the maximum spacing 3.7 m, or above the suspended ceilings of open construction, 3.0 m.

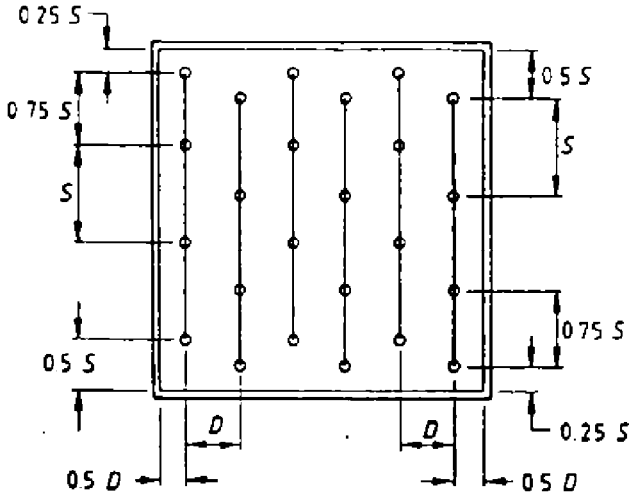
2) In cold storage warehouses using the air circulation method of refrigeration, corn, provender and rice mills not using pneumatic conveying, film and television production studios, the stage areas of theatres and above suspended ceilings, the area coverage of a sprinkler shall be not more than 9.0 m^2 and the spacing between sprinklers, along and between ranges shall be not more than 3.0 m.

3) 12 m^2 where there is no exposed structural steelwork, and where there is a clear space of not less than 2 m below the sprinklers.

The following figure is referred to in Table 25.



a) Standard layout (rectangular matrix)



b) Staggered layout for ordinary hazard systems where S is to exceed 4 m

CEILING SPRINKLER SPACING
Fig. 3

Key:

S is spacing between sprinklers on range pipes;

D is spacing between range pipes;

All dimensions shown are in meters.

TABLE 26 - MAXIMUM COVERAGE AND MAXIMUM SPACING FOR SIDEWALL SPRINKLERS

Hazard class	Maximum area coverage per sprinkler m^2	Spacing along walls		Room width		Room length	Number of rows of sidewall sprinklers	Spacing pattern (horizontal plane)
		Between sprinklers m	Sprinkler to wall end m	more than m	not more than m	m		
Light	17	4.6	2.3	—	3.7	Any	1	Single line
				3.7	7.4	Not more than 9.2	2	Standard
						More than 9.2	2	Staggered
				7.4	—	Any	2*	Standard
Ordinary	9	3.4¤	1.8	—	3.7	Any	1	Single line
				3.7	7.4	Not more than 6.8*	2	Standard
						More than 6.8*	2	Staggered
				7.4	—	Any	2	Standard*

*** Additional row or rows of roof or ceiling sprinklers required.**

¤ 3.7 m if the ceiling has a fire resistance of not less than 2 h.

¤ 7.4 m if the ceiling has a fire resistance of not less than 2 h.

22.1.4 Intermediate sprinklers in high-hazard occupancies

22.1.4.1 High-hazard intermediate sprinklers in non-shelved racks

Intermediate sprinklers shall be provided for palletized rack storage and multiple row drive through storage (see Type S5 in Table 1 of BS. 5306, Part 2) as specified in Table 28 as follows.

a) Single row racks not more than 3.2 m wide shall not be protected by single rows of sprinklers fitted or on the side of the stack used for access.

b) Racks more than 3.2 m wide, but not more than 6.0 m wide, shall be protected by two rows of sprinklers. The rows shall not be more than 3.2 m apart and the rows shall be the same distance from their nearer shelf edge. The sprinklers at a particular level in each line shall be located in the same set of transverse flues.

c) Double row racks not more than 3.2 m wide centrally in the longitudinal flue space shall be protected by sprinklers, at the stack ends, and at the tier levels specified in Table 27.

d) Where any rack or structural steelwork will significantly interfere with the water distribution from a sprinkler, an additional sprinkler shall be provided to compensate.

TABLE 27 - LOCATION OF INTERMEDIATE SPRINKLERS IN TYPE S5 STORAGE (BEAM PALLET RACKING)

Highest category of goods in the rack	Location of rows at least at	Maximum vertical distance between rows m	Each transverse flue and stack ends protected at least at	Maximum distance between sprinklers in row m	Minimum clearance between sprinkler deflector in any row and storage immediately below mm
I or II	every other tier	3.5	every fourth tier	2.8	150
III	every other tier	3.5	every alternate tier	1.4	150
IV	every tier	2.3	every alternate tier	2.8	150

22.1.4.2 High-hazard, intermediate sprinklers below solid or slatted shelves in racks

Intermediate sprinklers shall be provided above each shelf (including the top shelf if the roof or ceiling sprinklers are more than 3 m above the goods and water access to the goods is restricted), as given in Table 28. The maximum goods heights per shelf shall be as specified in Table 1 of BS 5306/Pt 2.

Single rows of sprinklers shall be central above shelves. Double rows shall be positioned so that the rows are the same distance from their nearer shelf edge.

The distance from the end of the shelf parallel to the range pipe lines to the nearest sprinkler shall be one-half the sprinkler spacing along the range lines or 1.4 m, whichever is less.

TABLE 28 - LOCATION OF INTERMEDIATE SPRINKLERS IN TYPE S7 STORAGE (SHELVED RACKS)

Goods high-hazard category	Shelf width		No. of rows of sprinklers	Maximum distance between sprinklers along rows m	Maximum distance between sprinkler rows m	Minimum clearance between sprinkler deflector in any row and storage immediately below mm
	over m	not exceeding m				
All	1.0	3.2	1	2.8	—	150
All	3.2	6.0	2	2.8	2.8	150

22.1.5 Minimum spacing between sprinklers

Sprinklers shall not be spaced less than 2.0 m apart except as follows:

22.1.5.1 Either where the heat-sensitive elements of the sprinklers are protected from wetting by an adjacent sprinkler, either by a sheet metal baffle not less than 200 mm wide and 150 mm high located midway between the sprinklers (when the baffle is fitted on the range pipe its top edge shall extend above the sprinkler deflector by 50 mm to 75 mm), or by an intervening constructional feature; or

22.1.5.2 Where the sprinkler spacing in a rack is determined by the distance between transverse flues in the racks (see Table 27).

22.1.6 Maximum sprinkler spacing from boundaries

22.1.6.1 Non-sidewall sprinklers:

a) Standard layout shall be used and no part of the boundary shall be more than 1.5 m from a line projected along the range lines, or perpendicular to the range lines through the sprinklers, where the following apply:

1) Ceilings are open joisted; or

2) the roof has rafters exposed; or

3) external walls are of combustible material; or

4) external walls are of asbestos cement or metal, with a combustible lining; or

5) external walls are of metal (whether on wood or metal frame with or without combustible lining) protected with a coating of bitumen, tar or pitch or with material impregnated with bitumen, tar or pitch; or

6) the boundary is the open face of building.

b) Where the boundary is a notional boundary or wall between hazards of differing classes the sprinkler/boundary spacing shall be as specified in Table 29 or 30 as appropriate.

TABLE 29 - MAXIMUM NEAREST DISTANCE OF SPRINKLERS IN STANDARD LAYOUT FROM A BOUNDARY PERPENDICULAR OR PARALLEL TO RANGE LINES

Hazard class	Maximum distance between sprinkler and nearest point on a boundary	
	Measured perpendicular to range pipe m	Measured along line of range pipe m
Light	0.5D*	0.5S*
Ordinary	0.5D*	0.5S*
High	0.5D*	0.5S*

*** See Fig. 3 for D and S.**

TABLE 30 - MAXIMUM NEAREST DISTANCE OF SPRINKLERS IN A STAGGERED LAYOUT FROM A BOUNDARY PERPENDICULAR OR PARALLEL TO RANGE LINES

Hazard class	Maximum distance between sprinkler and nearest point on a boundary	
	Range parallel to boundary m	Range perpendicular to boundary m
Ordinary	0.5D*	0.5S* and 0.25S* on alternate range lines

*** See Figure 3 for D and S.**

c) Where the boundary is irregular or is not perpendicular or parallel to a line of sprinklers, no part of the boundary shall be more than ½ $(S^2+D^2)^{½}$ from a sprinkler.

22.1.6.2 Sidewall sprinklers

Sidewall sprinklers shall be located with the deflector vertical center line not less than 50 mm and not more than 150 mm from the wall face against which they are mounted.

22.1.7 Clear space below sprinklers

Throughout the protected area the clear space below the level of non-intermediate sprinkler deflectors shall not be less than:

22.1.7.1 For high-piled combustible stock 1.0 m.

22.1.7.2 For sprinklers above open suspended ceilings: 0.8 m.

22.1.7.3 For other than 22.1.7. or 22.1.7.2 0.5 m.

Where goods are stored below sloping roofs or ceilings with the top of the goods following the slope, roof trusses shall be accessible at all times to the water discharge if sprinklers operate.

22.1.8 Sprinkler location relative to building structure and plant

22.1.8.1 Roofs and ceilings, without bays or beams

The following shall apply:

a) Sprinklers, other than sidewall and ceiling or flush pattern sprinklers. The deflector of a sprinkler other than a sidewall or ceiling/flush sprinkler shall be:

1) Not less than 75 mm below the underside of the roof or ceiling; and
2) not more than 450 mm below the roof or ceiling; and
3) not more than 150 mm below any exposed rafter of joist.

b) Sidewall sprinklers

The deflector of a sidewall sprinkler shall not be less than 100 mm and not more than 150 mm below the ceiling.

22.1.8.2 Roofs and ceilings, with beams but without bays

The following shall apply:

a) Sprinklers other than sidewall sprinklers

Where a beam or joist is so deep that a sprinkler cannot be located below the beam or joist as specified in 22.1.8.1 it shall be located above the base of the beam or joist, at a distance below the ceiling as specified in 22.1.8.1 at the appropriate horizontal distance from the beam or joist.

b) Sidewall sprinklers

Any beam or other obstruction below the ceiling within a rectangle centered on the sprinkler, of dimensions A × 2B (See Table 31) shall not exceed the depth given in Table 31.

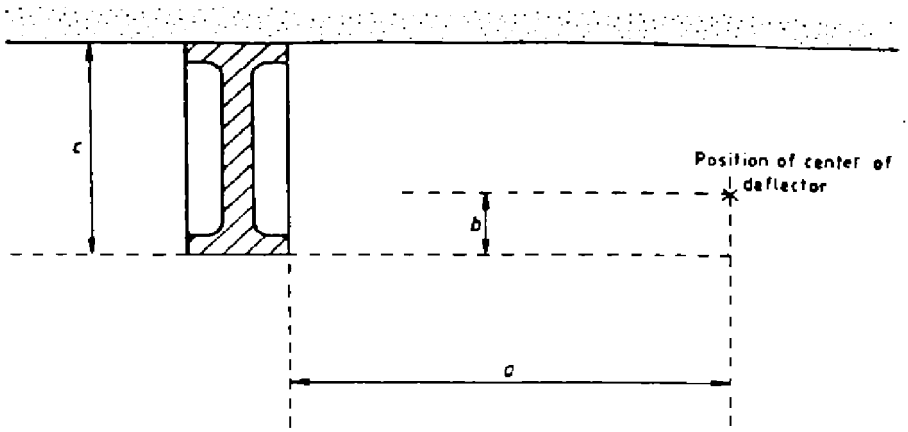
Any obstruction below the plane of the ceiling within a rectangle 1 m either side of a sprinkler by 1.8 m from the wall shall be regarded as a boundary.

TABLE 31 - MINIMUM DISTANCE OF SIDEWALL SPRINKLERS FROM BEAMS UNDER FLAT CEILINGS

Depth of beam		Minimum horizontal distance, sprinkler/wall to beam	
greater than mm	not greater than mm	Perpendicular to wall Dimension A m	Parallel to wall either side of sprinkler Dimension B m
0	100	1.8	1.0
100	125	2.1	1.2
125	150	2.4	1.4
150	175	2.7	1.6
175	200	3.0	1.8

22.1.8.3 Roofs and ceilings with bays and/or deep beams

Where the depth of a beam or joist (see dimension C in Fig. 4) exceeds 300 mm for combustible ceilings or 450 mm for non-combustible ceilings, or other obstructions from ceiling bays so that the requirements of 22.1.8.1 and/or 22.1.8.2 cannot be met, then the obstruction or the beam or joist shall be regarded as a boundary.



SPRINKLER LOCATION RELATIVE TO BEAMS
Fig. 4

Key:

- ***a*** Minimum horizontal distance.
- ***b*** Distance of deflector above (+) or below (-) bottom of beam or joist.
- ***c*** Depth of beam or joist.

22.1.8.4 Spacing of sprinklers under pitched roofs

a) Branch lines parallel to peaks of pitched roofs and sprinklers on lines perpendicular to peaks shall be spaced throughout the distance measured along the slope. This will place a row of sprinklers either in the peak or one-half the spacing down the slope from the peak.

b) Under saw-toothed roofs, the row of sprinklers at the highest elevation shall not be more than (0.9 m) down the slope from the peak.

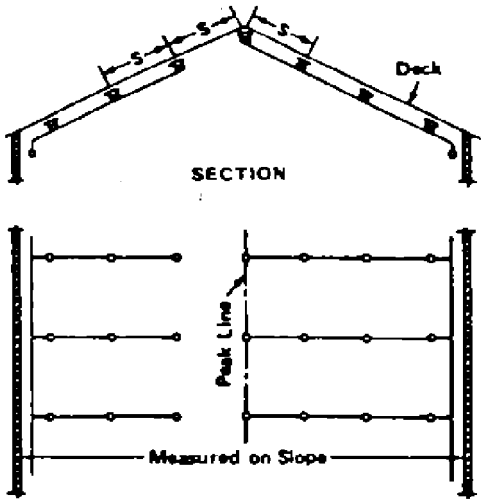
c) In (a) and (b) above sprinklers in or near the peak shall have deflectors located not more than (0.9 m) vertically down from the peak. [See Figs. 4(a) and 4(b).]

Exception:

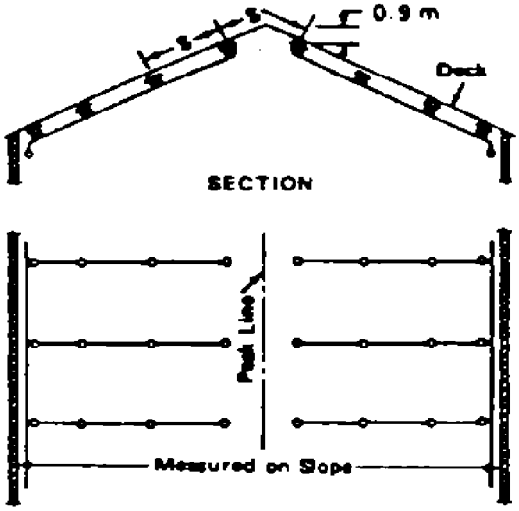
In a steeply pitched roof the distance from the peak to the deflectors may be increased to maintain a horizontal clearance of not less than (0.6 m) from other structural members. [See Fig. 4(c).]

22.1.8.5 Spacing of sprinklers under curved roof buildings

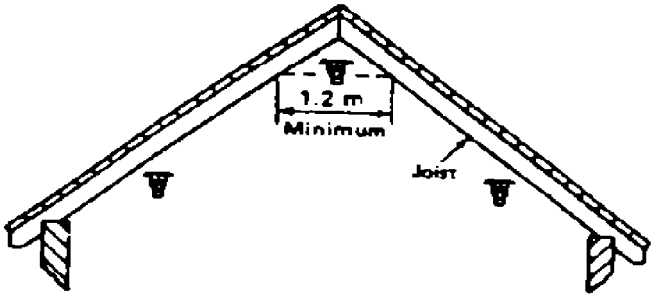
a) When roofs are curved down to the floor line, the horizontal distance measured at the floor level from the sidewall or roof construction to the nearest sprinklers shall not be greater than one-half the allowable distance between sprinklers in the same direction.



SPRINKLERS AT PITCHED ROOFS, BRANCH LINES RUN UP THE SLOPE
Fig. 4 (a)



SPRINKLERS AT PITCHED ROOFS, BRANCH LINES RUN UP THE SLOPE
Fig. 4 (b)



DESIRABLE HORIZONTAL CLEARANCE FOR SPRINKLERS AT PEACK OF PITCHED ROOF
Fig. 4 (c)

22.1.9 Columns

a) Where a roof or ceiling sprinkler is less than 0.6 m from the face of a column another sprinkler shall be located not more than 2.0 m from the opposite side of the column.

Sprinklers should be located as far as possible from columns.

b) High-piled storage, types S2, S3, S4, S5, S6 and S7*. Any column, of less than 2 h fire resistance, surrounded by high-piled storage of class S2, S3, S4, S5, S6, or S7, shall have provision for cooling spray from small orifice narrow angle sealed sprayers. There shall be one sprayer located on each side of the column at the level of the top

of the storage with lower opposed pairs of sprayers, at intervals not exceeding 4.5 m, to the base of the column. Where there are obstructions to water down flow sprayers shall be located immediately below each obstruction.

The sprayers shall be directed to wet the surface area of the structural member (with water impinging on any column web) at a rate of 10 mm/min related to the surface area of the structure over a 4.5 m length.

The water for column protection is added to that required for the normal installation.

22.1.10 Girders

a) Where the top flange of a girder is not more than 200 mm nominal width sprinklers shall be positioned either not less than 1.2 m from the side of the girder (viewed in plan), or directly above the girder with the deflector not less than 150 mm above the top face.

b) Where the top flange of a girder is more than 200 mm nominal width sprinklers shall be positioned not less than 1.2 m from the side of the girder (viewed in plan).

22.1.11 Roof trusses

a) Where the truss members are not more than 100 mm wide sprinklers shall be positioned either not less than 0.3 m from the side of the truss (viewed in plan), or equidistant from each side of the truss with the deflector not less than 150 mm above any truss member.

b) Where the truss members are more than 100 mm and less than 200 mm wide, sprinklers shall be positioned either not less than 0.6 m from the side of the truss (viewed in plan) or equidistant from each side of the truss with the deflector not less than 150 mm above any truss member.

c) Where the truss members are more than 200 mm wide sprinklers shall be positioned not less than 0.6 m from the side of the truss (viewed in plan).

22.1.12 Concealed spaces

a) All concealed spaces enclosed wholly or partly by exposed combustible construction shall be protected by sprinklers.

Exceptions:

1) Spaces formed by studs or joists with less than (152 mm) between the inside or near edges of the studs or joists.

2) Spaces formed by bar joists with less than (152 mm) between the roof or floor deck and ceiling.

3) Spaces formed by ceilings attached directly to or to within (152 mm) of wood joist construction.

4) Spaces formed by ceilings attached directly to the underside of composite wood joist construction, provided the joist channels are fire-stopped into volumes each not exceeding (4.53 m^3) using materials equivalent to the joists.

*** For types of storage see note under Clause 19.5.**

5) Spaces entirely filled with noncombustible insulation.

6) In wood joist construction and composite wood joist construction with noncombustible insulation filling the space from the ceiling up to the bottom edge of the joist of the roof or floor deck, provided that in composite wood joist construction, the joist channels are fire-stopped into volumes each not exceeding (4.53 m^3) using materials equivalent to the joists.

7) Small spaces over rooms not exceeding (4.6 m^2) in area.

8) When the exposed surfaces have a flame spread rating of 25 or less and the materials have been demonstrated not to propagate fire in the form in which they are installed in the space.

9) When the Btu content of the facing and substrate of insulation material does not exceed 1000 Btu per sq. ft. (11 356 kJ/m^2).

b) Sprinklers in concealed spaces having no access that will allow storage or other use shall be installed on the basis of Light Hazard Occupancy.

c) When heat-producing devices such as furnaces or process equipment are located in the joist channels above a ceiling attached directly to the underside of composite wood joist construction that would not otherwise require sprinkler protection of the spaces, the joist channel containing the heat-producing devices shall be sprinklered by installing two sprinklers in each joist channel, one on each side, adjacent to the heat-producing device. The temperature rating of the sprinklers shall be as prescribed in Table 32.

d) In concealed spaces having exposed combustible construction, or containing exposed combustibles, in localized areas, the combustibles shall be protected as follows:

1) If the exposed combustibles are in the vertical partitions or walls around all or a portion of the enclosure, a single row of sprinklers spaced not over (3.7 m) apart nor more than (1.8 m) from the inside of the partition may be installed to protect the surface. The first and last sprinklers in such a row shall not be over (1.5 m) from the ends of the partitions.

2) If the exposed combustibles are in the horizontal plane, permission shall be given to protect the area of the combustibles on a light hazard spacing and add a row of sprinklers not over (1.8 m) outside the outline of the area and not over (3.7 m) on center along the outline. When the outline returns to a wall or other obstruction, the last sprinkler shall not be over (1.8 m) from a wall or obstruction.

23. ELEVATORS, STAIRS AND FLOOR OPENINGS

23.1 Vertical Shafts

23.1.1 One sprinkler shall be installed at the top of all shafts.

23.1.2 When vertical shafts have combustible sides, one sprinkler shall be installed at each alternate floor level. When a shaft having combustible surfaces is trapped, an additional sprinkler shall be installed at the top of each trapped section.

23.1.3 When accessible shafts have noncombustible surfaces, one sprinkler shall be installed near the bottom.

23.1.4 When vertical openings are not protected by standard enclosures, sprinklers shall be so placed as to fully cover them. This necessitates placing sprinklers close to such openings at each floor level.

23.2 Stairways

23.2.1 Stairways of combustible construction shall be sprinklered underneath, whether risers are open or not.

23.2.2 Stairways of noncombustible construction with combustible storage beneath shall be sprinklered.

23.2.3 When moving stairways, staircases, or similar floor openings are unenclosed, the floor openings involved shall be protected by draft stops in combination with closely spaced sprinklers.

The draft stops shall be located immediately adjacent to the opening, shall be at least (457 mm) deep, and shall be of substantially noncombustible material that will stay in place before and during sprinkler operation. Sprinklers shall be spaced not more than (1.8 m) apart and placed (152 to 305 mm) from the draft stop on the side away from the opening to form a water curtain. Sprinklers in this water curtain shall be hydraulically designed to provide a discharge of [(37

L/min)/m] of water curtain, with no sprinklers discharging less than (56.8 L/min). The number of sprinklers calculated in this water curtain shall be the number in the length corresponding to the length parallel to the branch lines in the design area.*

The water supply for these sprinklers shall be added to the water supply required for the area of operation in hydraulically designed systems or to the water supply required as determined in accordance with Table 2.2.1.1 (a). (See Table in NFC, Volume 1, Section 13.)

Supplies shall be balanced to the higher pressure demand in either case. Sprinklers shall be nominal 12.7 mm, 11.1 mm or 9.5 mm orifice. When sprinklers are closer than (1.8 m), cross baffles shall be provided. When sprinklers in the normal pattern are closer than (1.8 m) from the water curtain, it may be preferable to locate the water curtain sprinklers in recessed baffle pockets.

Exception:

Closely spaced sprinklers are not required around large openings such as those found in shopping malls, show room buildings, and similar structures where all adjoining levels and spaces are protected by automatic sprinklers in accordance with this standard, when the openings have all horizontal dimensions between opposite edges of (6 m) or greater, and an area of (93 m^2) or greater.

23.2.4 In noncombustible stair shafts, sprinklers shall be installed at the top and under the first landing above the lowest level. When the stair shaft serves two or more separate fire sections, sprinklers shall also be installed at each floor landing.

23.3 Escalators

Sprinklers shall be Installed:

a) In the passenger carrying space; and
b) below the ceiling below the escalator; and
c) between the ceiling below the escalator and the passenger carrying space; and
d) in the escalator boot; and
e) in the motor space.

*** The water supply for sprinklers only shall be calculated either from the area/density or be based upon the room design method. (See Clause 7.4.3.1 in NFC, Volume 1, Section 13.)**

23.4 Machinery Pits and Production Lines

Machinery pits in which combustible waste may accumulate, and the undersides of production lines shall be fitted with sprinklers.

23.5 Obstructions Below Sprinklers

23.5.1 Platforms, heating panels etc.

Sprinklers shall be provided under the following:

a) Internal overhead platforms;
b) heating panels;
c) galleries;
d) walkaways;

Which are either:

1) More than 0.8 m wide and less than 150 mm from adjacent walls or partitions; or
2) More than 1.0 m wide.

23.5.2 Suspended ceilings

23.5.2.1 Suspended imperforate ceilings

A material used as an imperforate film below the sprinkler protection, e.g., to produce diffused lighting shall not be subject to partial collapse under incipient fire conditions. The material and its means of suspension shall be suitable for sprinkler use; thermoplastics materials shall not be used for imperforate suspended ceilings above storage areas or in high-hazardoccupancies.

23.5.2.2 Suspended open ceilings

The requirements of this standard shall not be applied where:

a) Suspended open ceilings are used above storage areas or in high-hazard occupancies;

b) the suspended open ceiling will prevent the efficient operation, or detract from the fire control, of the sprinklers installed above;

c) the ceiling supports are combustible;

d) the ceiling and its supports may drip molten particles under fire conditions;

e) the structural integrity of the ceiling and of any equipment, such as light fittings, installed within the volume above it may be affected by operation of the sprinkler installation;

f) the total plan area of the openings in the suspended open ceiling is less than 70% of the ceiling plan area;

g) services installed in the suspended ceiling, such as light fittings, reduce the open plan area of the ceiling below 60% of the total ceiling plan area;

h) the minimum dimension of the ceiling openings is less than 25 mm or the vertical thickness of the suspended ceiling whichever is the greater.

Obstructions within the ceiling void likely to cause significant interference with water distribution shall be treated as boundaries for the purpose of sprinkler spacing.

Where any obstruction, for example a light fitting, is more than 800 mm wide supplementary sprinklers shall be provided to discharge below the obstruction.

23.5.3 Ducts

Sprinklers shall be fitted below ducts which are:

a) Rectangular and more than 0.8 m and less than 150 mm from adjacent walls or partitions; or
b) circular and more than 1.0 m in diameter and less than 150 mm from adjacent walls or partitions; or
c) rectangular and more than 1.0 m in width; or
d) circular and more than 1.2 m in diameter.

23.5.4 Storage racks

Sprinklers shall be fitted to protect goods stored in racks.

23.5.5 Work tables

Sprinklers shall be fitted below work tables where there is a power source or where combustible process waste may accumulate.

23.5.5.1 Sprinklers shall be fitted in concealed spaces or cavities more than 100 mm deep between combustible linings and walls and roofs.

Any electric cables in the spaces should be run in screwed steel conduit or be of the mineral insulated metal sheathed type.

23.5.6 Theatres and similar premises

In addition to sprinklers at the roof or ceiling, sprinklers shall be fitted under the grid, the flies, the stage and any other obstruction to the discharge from the roof or ceiling sprinklers.

23.5.7 Computer areas

In computer areas concealed spaces forming cableways not fitted with either a carbon dioxide total flooding system shall be fitted with sprinklers.

23.5.8 Plastic roof lights

Sprinklers shall not be installed directly below roof lights of PVC, or plastics of similar thermal behavior and shall only be installed where:

a) The area of each rooflight does not exceed 5 m^2;

b) the distance between individual rooflights is not less than 1.8 m;

c) the total area of the rooflights in any communicating part of the building does not exceed 15% of the plan area of such part of the building.

The design of sprinkler systems to protect areas under plastic roof lights outside these limits is not covered by this standard.

24. TEMPERATURE RATINGS, CLASSIFICATIONS AND COLOR CODING

24.1 The standard temperature ratings of automatic sprinklers are shown in Table 32. Automatic sprinklers shall have their frame arms colored in accordance with the color code designated in Table 32, with the following Exceptions:

Exceptions:

1) The color identification for corrosion resistant sprinklers may be a dot on the top of the deflector, the color of the coating material, or colored frame arms.

2) Color identification is not required for ornamental sprinklers such as factory plated or factory painted sprinklers, or for recessed, flush, or concealed sprinklers.

24.2 Ordinary temperature rated sprinklers shall be used throughout buildings.

Exceptions:

1) Where maximum ceiling temperatures exceed (38°C), sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of Table 32 shall be used.

2) Intermediate and high-temperature sprinklers shall be used throughout Ordinary and Extra Hazard Occupancies.

3) Sprinklers of intermediate and high temperature classifications shall be installed in specific locations as required by clause 24.3.

4) When permitted or required by other NFPA Standards.

24.3 The following practices shall be observed to provide sprinklers of other than ordinary temperature classification unless maximum expected temperatures are otherwise determined, or unless high-temperature sprinklers are used throughout.

a) Sprinklers near unit heaters: Sprinklers in the heater zone shall be high and sprinklers in the danger zone intermediate temperature classification.

b) Sprinklers located within (305 mm) to one side or (762 mm) above an uncovered steam main, heating coil, or radiator shall be intermediate temperature classification.

c) Sprinklers within (2.1 m) of a low-pressure blowoff valve that discharges free in a large room shall be high temperature classification.

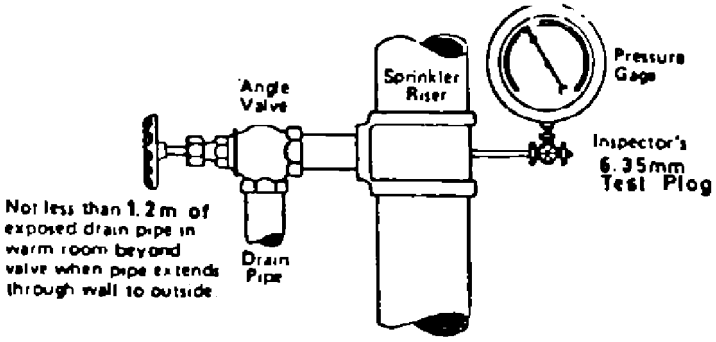
d) Sprinklers under glass or plastic skylights exposed to the direct rays of the sun shall be intermediate temperature classification.

TABLE 32 - TEMPERATURE RATINGS, CLASSIFICATIONS AND COLOR CODINGS

MAX. CEILING TEMP. °C	TEMPERATURE RATING °C	TEMPERATURE CLASSIFICATION	COLOR CODE FRAME ARM (See 24.1)	GLASS BULB COLORS
38	57 to 77	ORDINARY	UNCOLORED or BLACK	ORANGE or RED
66	79 to 107	INTERMEDIATE	WHITE	YELLOW or GREEN
107	121 to 149	HIGH	BLUE	BLUE
149	163 to 191	EXTRA HIGH	RED	PURPLE
191	204 to 246	VERY EXTRA HIGH	GREEN	BLACK
246	260 to 302	ULTRA HIGH	ORANGE	BLACK
329	343	ULTRA HIGH	ORANGE	BLACK

25. DRAINAGE

25.1 Provisions shall be made to properly drain all parts of the system. (See Fig. 5.)



DRAIN CONNECTION FOR SYSTEM RISER
Fig. 5

25.2 Drain connections for systems supply risers and mains shall be sized as shown in Table 33.

TABLE 33

RISER OR MAIN SIZE	SIZE OF DRAIN CONNECTION
Up to 51 mm	19 mm or larger
64 mm, 76 mm, 89 mm	32 mm or larger
1.2 mm and larger	51 mm only

25.3 Each interior sectional control valve shall be provided with a drain connection sized as shown in Table 33 so as to drain that portion of the system controlled by the sectional valve. These drains shall discharge either outside or to a drain connection.

25.4 The test valves shall be used as main drain valves.

25.5 Drain valves shall be fitted to allow drainage from:

25.5.1 Immediately downstream of the installation alarm valve or, if fitted, its downstream stop valve; and

25.5.2 Immediately down stream of any tail-end alarm valve; and

25.5.3 Immediately downstream of any subsidiary stop valve; and between a dry pipe or tail-end installation alarm valve and any subsidiary stop valve installed for testing; and

25.5.4 Any pipe other than drop pipes to single sprinklers in a wet installation which cannot be drained through another drain valve. The valves shall be fitted at the lower end of permanent pipework.

The outlet shall not be more than 3 m above the floor and shall be fitted with a brass plug.

25.6 Pipe Work Drainage

All installation pipework above ground shall be installed at not less than the designed slope to drain.

The slope to drain of distribution and range pipework shall be not less than as given in Table 34.

Where possible the pipework should slope to drain through the installation control valve drain valve. Where this cannot be achieved trapped sections of pipework, other than single sprinklers situated on drop pipe below suspended ceilings, should slope to the point of connection of another drain valve.

Deluge installation pipework which can drain thoroughly through the open nozzles need not be sloped to drain.

TABLE 34 - INSTALLATION PIPEWORK SLOPE TO DRAIN

INSTALLATION TYPE	PIPE SIZE mm	SLOPE TO DRAIN mm/m
		HORIZONTAL RUN OF PIPE
WET	ANY	2
ALL OTHERS	NOT MORE THAN 40	12
ALL OTHERS	MORE THAN 40	4

25.6.1 On wet-pipe systems, sprinkler pipes may be installed level. Trapped piping shall be drained in accordance with Clause 25.7.

25.7 Auxiliary Drains

25.7.1 Auxiliary drains shall be provided when a change in piping direction prevents drainage of sections of branch lines or mains through the main drain valve.

25.7.2 Auxiliary drains for wet-pipe systems

25.7.2.1 When the capacity of trapped sections of pipes is (18.9 L) or less, the auxiliary drain shall consist of a nipple and cap or brass plug not less than (19 mm) in size.

Exception:

Auxiliary drains are not required for piping that can be drained by removing a single pendent sprinkler.

25.7.2.2 When the capacity of isolated trapped sections of pipe is more than (18.9 L) and less than (189 L), the auxiliary drain shall consist of a valve not smaller than (19 mm) in size and a plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap may be used.

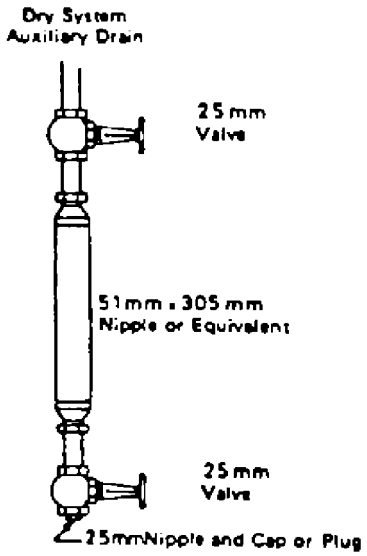
25.7.2.3 When the capacity of isolated trapped sections of pipe is (189 L) or more, the auxiliary drain shall consist of a valve not smaller than (25 mm), piped to an accessible location.

25.7.2.4 Tie-in drains are not required on wet-pipe systems.

25.7.3 Auxiliary drains for dry-pipe systems

25.7.3.1 When capacity of trapped sections of pipe is (18.9 L) or less, the auxiliary drain shall consist of a valve not smaller than (19 mm) and a plug, at least one of which shall be brass. In lieu of a plug, nipple and cap may be used.

25.7.3.2 When capacity of isolated trapped sections of pipe is more than (18.9 L), the auxiliary drain shall consist of two (25 mm) valves, and one (51 mm by 350 mm) condensate nipple or equivalent, accessibly located. (See Fig. 6.)



DRY SYSTEM AUXILIARY DRAIN
Fig. 6

25.7.3.3 Tie-in drains shall be provided for multiple adjacent trapped branch lines and shall be minimum of (25 mm). Tie-in drain lines shall be pitched a minimum of (4 mm/m).

25.7.4 Auxiliary drains for reaction systems

25.7.4.1 When trapped sections of pipe are in areas subject to freezing, auxiliary drains shall conform to 25.7.3.

25.7.4.2 When trapped sections of pipe are in areas not subject to freezing, auxiliary drains shall consist of a valve not smaller than (19 mm) and a plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap shall be used.

Exception:

Auxiliary drains are not required for piping that can be drained by removing a single pendent sprinkler when capacity of the trapped sections of pipe is (18.9 L) or less.

26. ALARMS AND ALARM DEVICES

26.1 Water Motor Alarms

26.1.1 General

Each installation main control valve set shall be provided with a water motor alarm suitable for sprinkler service located as close as possible to the alarm valve.

In addition hydraulic alarms may be fitted to subsidiary manual deluge installation control valves and as an option for subsidiary computer room protection.

The water supply motor alarm of a high-rise installation shall be driven by the town main or other secondary supply, controlled by a diaphragm valve connected to the main installation control alarm valve port.

26.1.2 Gong and water motor

The water motor shall be installed with its gong on the outside of an exterior wall and with its center line not higher than 6 m above the point of connection to the alarm valve. A strainer, readily accessible for cleaning, shall be fitted between the motor nozzle and the alarm valve connection. The water outlet shall be positioned so that any flow of water can be seen.

26.1.3 Prevention of false and intermittent alarms

Any device to reduce the frequency of false or intermittent alarms fitted to the installation shall be suitable for sprinkler service. False alarms caused by wide fluctuations of town mains pressure may be prevented by the use of a retard chamber, or a jockey pump.

Intermittent alarms may be caused by an excessive amount of air trapped in the installation. Reduction of the amount of air will reduce the frequency of alarms, but it is essential that some air be retained to prevent dangerous overpressure caused by temperature changes. Intermittent alarms shall be prevented by the use of an air bottle arrangement on the pipe to the water motor.

26.2 Electric Water Flow and Water and Air Pressure Switches

26.2.1 General

26.2.1.1 Electric water flow alarm switches and water and air pressure alarm switches fitted to sprinkler installations shall be suitable for sprinkler service.

26.2.1.2 Either an electric water flow alarm switch or an electric alarm pressure switch shall be fitted where an electric alarm device to indicate operation of sprinklers is specified.

26.2.2 Water flow alarm switches

A water flow alarm switch shall detect any flow equal to, or more than, that from any single sprinkler. A test facility shall be fitted immediately downstream of the switch. The test facility shall simulate operation of a single sprinkler and shall be fitted with a drain.

26.2.3 High-rise installations

A water flow alarm switch shall be fitted to each zone of a high-rise installation, immediately downstream of the subsidiary stop valve.

26.2.4 Cold storage warehouses

26.2.4.1 An electric alarm device to indicate operation of sprinklers shall be fitted downstream of each tail-end extension alarm valve.

26.2.4.2 Each discrete section of the installation pipework shall be provided with a low air/gas pressure alarm. These shall provide a visual and audible warning in an area with responsible manning.

Where a dry installation control valve set feeds one or more tail-end dry extensions, a low gas/air pressure switch should be fitted immediately downstream of the main valve set and also on each tail-end valve set.

26.2.5 Stop valve mode indicator switches

26.2.5.1 General

Indicator switches provided to monitor the mode of stop valves (i.e., either fully open or not fully open) shall be fitted with a tamper detection device which will cause the mode change alarm to operate.

26.2.5.2 Life safety systems

All stop valves on the premises which control the flow of water to sprinklers, i.e., stop valves at any point in the water supply pipework, whether part of the main installation control valve set, including the bypass valve or upstream or downstream of it, shall be fitted with a tamper-proof electric switch to indicate that the valve is in the correct operational mode.

26.3 Indicator Panels and Alarms

26.3.1 General

Indicator panels and alarms shall comply with the appropriate requirements. (See IPS-E-SF-260.)

26.3.2 Electrically driven suction and booster pumps

Separately switched sub-circuits shall be used to supply both:

a)

- The pump(s); and
- any mains powered mains failure alarm system; and

b)

- any pump which will be the first to start when the water supply pressure drops to the appropriate pressure; and
- any mains powered low supply pressure alarm system.

Any battery for automatic power failure alarm shall be trickle-charged and shall have a capacity to provide an alarm of 72 h duration. The battery shall not be used for automatic starting of a diesel engine driven pump or for any non-fire protection purpose.

26.3.3 Diesel engine driven suction and booster pumps

Any battery power supply for the indicator panel or alarm system shall not be supplied from batteries provided to start the diesel engine(s).

26.3.4 Pressure tanks

Separately switched sub-circuits shall be used to supply:

a) The water supply pump and/or air compressor; and
b) any mains powered alarm system for water level and air pressure.

26.3.5 Life safety

26.3.5.1 Alarms and indications

Monitoring devices shall be provided to give alarms or indications that:

a) The downstream and upstream stop valves to each installation control main valve set are fully open; or,

where one of the pairs of stop valves on either side of an alarm valve has both stop valves fully open and that the stop valves on each side of the duplicate alarm valve are closed; and,

b) each zone subsidiary stop valve is fully open;

c) the static pressure in any trunk main supplying the system has fallen to a value 0.5 bar or more below the normal static pressure; and,

d) water flow equivalent to that from one or more sprinklers into the installation is taking place.

26.3.5.2 Indicator panel

The monitoring devices specified in 26-3-5-1 (a) shall be connected electrically to an indicator panel suitable for sprinkler use where the following indications shall be given:

a) By means of the necessary number of green visual indicators that the devices specified in 26.3.5.1 (a) and (b) are in the normal condition;

b) by means of audible and visible warnings by the necessary number of yellow visual indicators that:

1) Either the downstream or upstream or both main installation control valve set stop valves are not fully open in the legs, or in one leg. One visual indicator per valve set is sufficient;

2) any zone control stop valve is not fully open (one visual indicator per zone is sufficient);

3) the mains static water pressure in the trunk main is low [see 26.3.5.1 (c)].

c) by means of audible and visible (red indicator) warnings, that water is flowing into the installation at a rate exceeding $20\ ^{+37}_{-0}$ L/min.

Facilities may be provided at the indicator panel for silencing the audible alarms but the visual indicators shall continue to operate until the installation is restored to the normal standing condition.

Any change in the panel alarm or fault indication after the audible alarm has been silenced shall cause it to resume sounding until it is again silenced or the panel reset to the normal standing condition.

26.3.5.3 Power supplies

The indicating equipment shall be mains powered but standby power supply shall be immediately available in the event of failure of the normal power supply.

26.3.6 Computer areas

A subsidiary stop valve, controlling that part of an installation protecting a computer area, shall be electrically monitored at a continuously manned position. Closure or partial closure of the valve shall be signaled by a visible and by an audible alarm.

26.3.7 Linking to general alarm systems

Where a sprinkler installation is provided with a device or devices which will automatically operate electric powered audible alarms for the purpose of general alert or building evacuation, the device(s), the alarm, the linking control and the indicating equipment shall comply with IPS-E-SF-260.

26.3.8 Systems for transmission of alarms to a fire brigade

26.3.8.1 General

Any system provided to automatically transmit, on operation of the sprinkler installation, an alarm to a fire brigade or to a remote manned center, shall be suitable for sprinkler service.

26.3.8.2 Transmission system

There shall be a direct connection from the alarm signaling device to:

a) A permanently manned public fire brigade watchroom or control room, or a public fire brigade control terminating in a watchroom or control room; or,

b) A permanently manned suitable central fire alarm depot, communicating directly with the public fire brigade or public fire brigade control as in item (a); or

c) permanently manned watchroom of a suitable private fire brigade.

27. HAZARD TO PERSONNEL

27.1 High Temperature Liquids

Sprinklers shall not be installed in locations where water discharge from sprinkler heads or sprayers, or water leakage from installation pipework, may come into contact with high-temperature liquid baths such as salt baths, metal melt pans, frying ranges, hot dip bitumen baths etc.

27.2 Water Reactive Chemicals

The consequences of sprinkler water discharge onto water reactive chemicals below shall be considered and safe storage and usage practices adopted.

Water discharge may ignite certain chemicals, or cause a violent reaction and/or emission of poisonous or noxious fumes.

Where water run-off from sprinkler discharge is dangerous owing to contact with water-soluble chemicals or by water-borne dispersion of hazardous materials, construction of suitable drains, sumps, bunds etc. should be considered at the planning stage.

27.3 Electrical Earthing

27.3.1 All exposed metalwork in systems shall be efficiently earthed to prevent the metalwork becoming electrically charged.

27.3.2 Sprinkler pipework shall not be used as a means of earthing electrical equipment.

27.4 During Maintenance

Where sprinkler or deluge installation pipework is normally unpressurized, work shall not be undertaken involving removal or fitting of sprinkler heads or water sprayers when operation of the installation is possible unless measures are taken to ensure the safety of the erection personnel concerned.

28. OUTSIDE SPRINKLERS FOR PROTECTION AGAINST EXPOSURE FIRES

28.1 Water Supply

28.1.1 Sprinklers installed for protection against exposure fires shall be supplied from a standard water supply as outlined in 18.

28.1.2 The water supply should be capable of furnishing the total demand for all exposure sprinklers operating simultaneously for protection against the exposure fire under consideration for a duration of not less than 60 minutes.

28.1.3 When automatic systems of sprinklers are installed, water supplies shall be from an automatic source.

28.1.4 When fire department connections are used for water supply, they shall be so located that they will not be affected by the exposing fire.

28.2 Control

28.2.1 Each system of outside sprinklers shall have an independent control valve. When more than one system is required, the division between systems shall be vertical and not horizontal.

Exception:

When more than six lines are installed, the systems shall be divided horizontally with independent risers.

28.2.2 Manually controlled open sprinklers shall be used only where constant supervision is present.

28.2.3 Automatic systems of open sprinklers shall be controlled by the operation of fire detection devices designed for the specific application.

28.3 Water Supply

28.3.1 Pipe sizes of lines, risers, feed mains and water supply shall be hydraulically calculated in accordance with Clause 20.2.5 to furnish a minimum of 0.5 bars at any sprinklers with all sprinklers facing the exposure operating, or pipe sizes shall be in accordance with Clause 20.2.5.

28.4 Type

28.4.1 Small orifice sprinklers will normally be used where exposure is light or moderate, the area of coverage is small, or where one horizontal line of window sprinklers is installed at each floor level.

28.4.2 Large orifice sprinklers will normally be used where exposure is severe, or where one horizontal line of window sprinklers is used to protect windows at more than one floor level.

28.5 Window Sprinklers

28.5.1 When the exposure hazard is light or moderate, and only one horizontal line of sprinklers is installed, the sprinklers should have 9.5 mm orifices. Where conditions require more than one line of sprinklers, the sprinklers should have orifices as shown below:

	2 Lines	3 Lines	4 Lines	5 Lines	6 Lines
Top Line	9.5 mm	9.5 mm	9.5 mm	9.5 mm	9.5 mm
Next below	8 mm	8 mm	9.5 mm	9.5 mm	9.5 mm
Next below		6.5 mm	8 mm	8 mm	8 mm
Next below			6.5 mm	8 mm	8 mm
Next below				6.5 mm	6.5 mm
Next below					6.5 mm

28.5.2 Where there are more than six horizontal rows of windows, sprinklers over the first story shall be omitted. Sprinklers shall also be omitted over the second story windows if a field test indicates wetting of all surfaces.

28.5.3 Large orifice sprinklers shall be used for protecting windows in two or three stories from one line of sprinklers. This will be determined by window and wall construction, such that all parts of the windows and frames will be thoroughly wetted by a single line of sprinklers.

28.5.4 For buildings not over three stories in height, one line of sprinklers will often be sufficient, located at the top story windows. For buildings more than three stories in height, a line of sprinklers shall be used in every other story beginning at the top.

With an odd number of stories, the lowest line can protect the first three stories. When several lines are used, the orifice should be decreased one size for each successive line below the top. In no case should an orifice less than 13 mm be used.

28.5.5 For windows not exceeding 1.5 m wide protected by small orifice sprinklers, one sprinkler should be placed at the center near the top, so located that water discharged therefrom will wet the upper part of the window and, by running down over the frame and glass, wet the entire window. This may ordinarily be accomplished by placing one sprinkler in the center with the deflector about on a line with the top of the upper sash and 178, 203 and 229 mm in front of the glass, with windows 0.9, 1.2 and 1.5 m wide respectively. When windows are over 1.5 m wide, or where mullions interfere, two or more sprinklers should be used.

28.5.6 When windows are 0.9 m or less in width, an orifice a size smaller than that required by 28.5 shall be used, but in no case should the orifice be smaller than 6.4 mm.

28.5.7 For windows up to 1.5 m wide protected by large orifice sprinklers use one 13 mm sprinkler at the center of each window. For windows from 1.5 to 2.1 m wide, use a 16 mm sprinkler at the center of each window. For windows from 2.1 to 2.9 m wide use one 19 mm sprinkler at the center of each window. For windows from 2.9 to 3.7 m wide, use two 13 mm sprinklers at each window.

28.5.8 Large orifice wide-deflector sprinklers should be placed with deflectors 51 mm below the top of the frame and 305 to 380 mm out from the glass.

When the face of the glass is close to the exterior wall, cantilever brackets or similar type hangers shall be used to maintain the window sprinklers 305 to 380 mm out from the glass.

28.6 Cornice Sprinklers

28.6.1 The discharge orifice should be at least 9.5 mm in diameter except, when the exposure is severe, 13 mm or 16 mm cornice sprinklers should be installed.

28.6.2 Sprinklers should not be more than 2.4 m apart, except as noted in 22.1.8.3 projecting beams or other obstructions shall make additional sprinklers necessary.

28.6.3 For cornices with bays up to 2.4 m wide sprinklers should be placed in the center of each bay. For cornices with bays from 2.4 to 3.0 m wide sprinkler orifices should be increased one size.

28.6.4 Cornice sprinklers should be located with deflectors approximately 203 mm below the roof plank.

28.6.5 When wood cornices are 762 mm or less above the windows, cornice sprinklers shall be supplied by the same pipe used for window sprinklers.

28.6.6 Where the overhang of the cornice is not over 0.3 m window sprinklers should be used and be spaced as follows:

9.5 mm and 13 mm sprinklers	**not more than 1.5 m apart;**
16 mm sprinklers	**not more than 2.1 m apart;**
19 mm sprinklers	**not more than 2.7 m apart.**

28.6.7 The window sprinklers should be placed above the pipe near the outer edge of the cornice with deflectors not more than 76 mm down from the cornice and at such an angle as to throw the water upward and inward.

28.6.8 With an overhang of more than 0.3 m cornice sprinklers should be used.

29. DELUGE FOAM-WATER SPRINKLER AND FOAM-WATER SPRAY SYSTEMS

29.1 General Information

29.1.1 This Standard covers the minimum requirements for open head deluge-type foam-water sprinkler systems and foam-water spray systems, each of which combines in a single system provision for the alternate discharge of foam or water.

29.1.2 Accordingly, systems can be designed with the required density for either foam or water application as the controlling factor, depending on the design purpose of the protection.

29.1.3 The devices covered herein are intended primarily for use in foam-water deluge sprinkler systems, or foam-water spray systems. This standard is not applicable where separate foam, water sprinkler or water-spray fixed systems are to be installed.

29.2 Purpose

The purpose of this Standard is to provide a reasonable degree of protection for life and property from fire through installation requirements for foam-water deluge sprinkler systems and foam-water spray systems based upon sound engineering principles, test data and field experience.

29.3 System Design

29.3.1 Automatic operation shall be provided and supplemented by auxiliary manual tripping means.

Exception:

Manual operation only can be provided when acceptable to the authorities concerned

29.3.2 Systems shall deliver foam for a definite period at given densities [(L/min) m^2] to the hazards they protect, either prior to water discharge or following water discharge, depending upon system-design purpose.

29.3.3 Following completion of discharge of foam to the hazards protected, these special systems shall discharge water until manually shut off.

29.3.4 IP authorities shall be consulted as to the means by which a reserve supply of foam concentrate shall be made available. The purpose of a reserve supply of concentrate is to have available the means for returning systems to service-ready condition following system operation. Reserve supply shall be listed for use with system components.

29.4 Applicability

29.4.1 Systems of this type shall discharge foam or water from the same discharge devices. In view of this dual extinguishing agent discharge characteristic, these systems are selectively applicable to combination Class A and Class B hazards.

Note:

Caution must be exercised when auxiliary extinguishing equipment is used with these systems. Some extinguishing agents will be incompatible with some foams.

29.4.2 Foam-water deluge systems are especially applicable to the protection of most flammable-liquid hazards. They can be used for any of the following purposes or combinations thereof:

a) Extinguishment

The primary purpose of such systems is the extinguishment of fire in the protected hazard. For this purpose, suitable foam-solution discharge densities (L/min)/m^2] shall be provided by system design and use of selected discharge devices; and by provision of adequate supplies of air-water at suitable pressures to accomplish the system design. Foam-discharge rates shall be suitable for the design period and following depletion of foam concentrate supplies, to provide similar rates of water discharge from the system until shut off.

b) Prevention

Prevention of fire in the protected hazard is a supplemental feature of such systems. Manual operation of a system to selectively discharge foam or water from the discharge devices in case of accumulations of hazardous materials from spills in such occupancies as garages, aircraft hangars, petrochemical plants, or from other causes in the protected area, will afford protection against ignition pending clean-up measures. In such cases, manual system operation can provide for foam coverage in the area with water discharge manually available.

c) Control and exposure protection

Control of fire to permit controlled burning of combustible materials where extinguishment is not practicable, and exposure protection to reduce heat transfer from an exposure fire may be accomplished by water spray and/or foam from these special systems, the degree of accomplishment being related largely to the fixed discharge densities provided by the system design.

29.4.3 Foam of any type is not considered a suitable extinguishing agent on fires involving liquefied or compressed gases, e.g., butane, butadiene, propane, etc., or on materials that will react violently with water (e.g., metallic sodium) or that produce hazardous materials by reacting with water, or on fires involving electrical equipment where the electrical nonconductivity of the extinguishing agent is of first importance.

29.4.4 Ordinary foam concentrates shall not be used on fires in water-soluble solvents and polar solvents. Special "alcohol-type" concentrates are available for production of foams for protection of such hazards.

29.4.5 The design discharge rates for water or foam solution shall provide densities of not less than [6.5 (L/min) m^2)] of protected area. This minimum density is required because this is a dual-agent foam-water system.

29.4.6 The foam discharge shall continue for a period of 10 min. at the design rate specified in 29.4.5. If the system discharges at a rate above the minimum specified in 29.4.5, then the operating time may be reduced proportionately, but shall not be less than 7 min.

29.5 System Components

29.5.1 Approved devices and materials

All components parts including foam concentrates of foam-water sprinkler and foam-water spray systems shall be listed for the intended application.

29.5.2 Discharge devices

Discharge devices should be air aspirating such as foam-water sprinkler and foam-water spray nozzles, or they can be non-air-aspirating, such as standard sprinklers.

29.5.3 Discharge devices and foam concentrates shall be listed for use together.

29.5.4 Non-air aspirating devices shall be used only with concentrates, such as AFFF, that have been tested and listed for use in these devices.

29.6 Foam Concentrates

29.6.1 Foam concentrates shall be listed for use with the concentrate proportioning equipment and with the discharge device to be used.

29.6.2 The quantities of foam concentrates to be provided for foam-water sprinkler and spray systems shall be sufficient to maintain the discharge densities for the application time period used as a base in system design.

29.6.3 There shall be a readily available supply of foam concentrate sufficient to meet the design requirements of the system to put the system back in service after operation. This supply can be in separate tanks or compartments, in drums or cans on the premises, or available from an outside source within 24 hours.

29.6.4 Replacement supplies of concentrates shall be checked by appropriate tests to determine acceptability.

29.7 Foam Concentrate Proportioning Means

29.7.1 Positive pressure-injection is the preferred method for introduction of foam concentrates into the water flowing through the supply piping to the system.

29.7.2 Positive pressure-injection methods shall mean one of the following:

a) Foam concentrate pump discharging through a metering orifice into the protection-system riser, with the foam pressure at the upstream side of the orifice exceeding the water pressure in the system riser by a specific design value.

b) A balanced-pressure proportioning system (demand type proportioner) utilizing a foam concentrate pump discharging through a metering orifice into a proportioning controller (venturi) or orifice in the protection system riser, with the foam, liquid, and water pressures automatically maintained equal by the use of a pressure control valve.

c) Pressure-proportioning tanks with or without a diaphragm to separate the water and foam concentrate.

29.7.3 Orifice plates shall have "tell-tale" indicators giving orifice diameters and indicating flow direction if flow characteristics vary with flow direction.

Note:

See A-2-4 (a) of BS 5306/Part 2 for formula for calculation of size of orifices used in metering foam concentrates.

29.7.4 Where special conditions warrant, other proportioning methods can be used, such as around-the-pump proportioners and in-line inductors.

29.8 Pumps

29.8.1 Foam concentrate pumps and water pumps shall have adequate capacities to meet the maximum needs of the system on which they are used. To ensure positive injection of concentrates, the discharge pressure ratings of pumps at the design discharge capacity shall be suitably in excess of the maximum water pressure available under any condition at the point of concentrate injection.

29.8.2 Foam concentrate pumps shall be carefully chosen and have adequate capacity for this special service and special attention shall be paid to the type of seals used with regard to the type of concentrate being pumped.

29.8.3 Provision shall be made to shut off the foam concentrate pump after the foam supply is exhausted.

29.9 Power Supply

29.9.1 Power supply for the drivers of foam concentrate pumps and water pumps shall be of maximum reliability. Compliance with the applicable requirements of NFPA 20, Standard for the Installation of Centrifugal Fire Pumps, covering the reliability of power supply for fire pump drivers, is considered to meet the intent of this standard.

29.9.2 Controllers governing the starting of foam concentrate pumps shall be of approved types. Control equipment shall comply with IPS Standard for the Installation of Centrifugal Fire Pumps.

29.10 Air Foam Concentrate Storage Tanks

29.10.1 Storage tanks for foam concentrates shall be of construction suitable for the liquid, solidly mounted, and permanently located.

29.10.2 Storage temperatures of foam concentrates shall be considered in locating storage tanks.

29.10.3 Storage tanks shall have capacities to accommodate only the needed quantities of foam concentrate plus adequate space for thermal expansion, the latter preferably to be accomplished by means of a vertical riser or expansion dome. Tanks meeting this requirement will have minimum surface areas in contact with air and liquid concentrates at the liquid level and thus minimize the possibility of interior corrosion of tanks. Foam concentrate outlets from tanks shall be raised above the bottoms of the tanks to provide adequate sediment pockets.

29.10.4 In determining the quantity of foam concentrates, the volume of the sediment pocket shall be added to the quantity needed for system operation.

29.10.5 Tanks shall be located to furnish a positive head on the pump suction.

29.11 Pressure on Foam Concentrate Lines

Where foam concentrate lines to the protective-system injection points are run underground or where they run aboveground for more than (15 m), foam concentrate in these lines shall be maintained under pressure to assure prompt foam application and to provide a means of checking on the tightness of the system. Pressure can be maintained by a small auxiliary pump, or by other suitable means.

29.12 Temperature of Foam Concentrate Lines and Components

Temperature of foam concentrate lines and components shall be maintained within the storage temperature limits specified for the foam concentrate.

29.13 Location of System-Control Equipment

29.13.1 Equipment items, such as storage tanks and proportioners for foam concentrates; pumps for water and foam concentrates; and control valves for water, concentrates, and foam solution shall be installed where they will be accessible, especially during a fire emergency in the protected area and where there will be no exposure from the protected hazard.

29.13.2 Automatically controlled valves shall be as close to the hazard protected as accessibility permits so that a minimum of piping is required between the automatic control valve and the discharge devices.

29.14 Detection Equipment

Detection equipment shall be installed, tested, and maintained in accordance with IPS-E-SF-260.

29.15 Alarms

29.15.1 A local alarm, actuated independently of water flow to indicate operation of the automatic detection equipment, shall be provided on each system. An alarm is not required on manually operated systems.

29.15.2 When an alarm is installed, the IP authorities shall be consulted regarding the alarm service to be provided and regarding the need for electrical fittings designed for use in hazardous locations in electric alarm installations.

29.15.3 A suitable trouble alarm shall be provided for each system to indicate failure of automatic detection equipment (including electric supervisory circuits) or other such devices or equipment upon which the system operation is dependent.

29.15.4 Alarm systems shall meet the applicable requirements of IPS-E-SF-260.

29.16 Strainers for Water and Foam Concentrates

29.16.1 Strainers shall be listed for fire protection service and shall be capable of removing from the water all solids of sufficient size to obstruct the discharge devices. Strainers shall be installed so as to be accessible for cleaning during an emergency. Space shall be provided for basket removal.

29.16.2 Strainers shall be installed in the main water supply lines feeding orifices (or water passage) smaller than 3/8 in.(9.6 mm). Strainers shall be installed on systems having larger orifices where water supply conditions warrant. Normally 1/8 in.(3.2 mm) perforations are suitable.

29.16.3 Strainers shall be installed in liquid concentrate lines up-stream of metering orifices or proportioning devices. Where listed strainers of the proper size are not available, strainers having a ratio of open-basket area to inlet pipe size of at least 10 to 1 shall be used.

29.17 Water Supplies

29.17.1 Types of water

29.17.1.1 Water supplied to deluge foam-water sprinkler systems and foam-water spray systems shall be free of constituents not compatible with air foam concentrates.

29.17.2 Water supply capacity and pressure

29.17.2.1 Water supplies for deluge foam-water sprinkler systems and foam-water spray systems shall be of capacity and pressure capable of maintaining foam discharge and/or water discharge at the design rate for the required period of discharge over the entire area protected by systems expected to operate simultaneously.

29.17.2.2 Water supplies shall be capable of supplying the systems at the design discharge capacity for at least 60 min.

29.18 Pipe Fittings

29.18.1 All fittings shall be of a type specifically approved for fire protection systems and of a design suitable for the working pressures involved, but not less than (1207 kPa) cold water pressures.

29.19 Automatic Detection

29.19.1 In automatic systems the detecting equipment shall be connected to means for tripping water deluge valves and other system-control equipment. Supplemental manual means for accomplishment of this purpose shall also be provided.

9.19.2 In automatic systems foam concentrate injection shall be activated automatically by, or concurrently with, activation of the main water-supply control valve. Manual operating means shall be designed to accomplish this same purpose.

29.19.3 Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with complete supervision so arranged that failure of equipment, loss of supervising air pressure, or loss of electric energy will result in positive notification of the abnormal condition.

29.19.4 Where used in a corrosive atmosphere, the devices shall be of materials not subject to corrosion or protected to resist corrosion.

29.19.5 Automatic detection equipment of electric type and any auxiliary equipment of electric type, if in hazardous areas, shall be expressly designed for use in such areas (see IPS-E-EL-110).

29.20 Hydraulic Calculations

29.20.1 System piping shall be hydraulically calculated and sized in order to obtain reasonably uniform foam and water distribution and to allow for loss-of-head in water supply piping. The adjustment in pipe sizes shall be based on a maximum variation of 15 percent above the specified discharge rate per sprinkler or nozzle.

29.20.2 Pipe sizes shall be adjusted according to detailed friction-loss calculations. These calculations shall show the relation between the water supply and demand.

29.20.3 Hydraulic calculations for determining the foam solution and water-flow characteristics of systems covered by this standard shall be in accordance with IPS-E-SF-140. Piping carrying foam solution shall be sized on the same basis as if it were carrying plain water.

29.20.4 The friction losses in piping carrying foam concentrate shall be calculated using the Darcy formula (also known as the Fanning formula). Friction factors for use with this formula shall be selected from the charts, Friction Factors for Commercial Steel and Cast-Iron Pipe [see A.1.3 for formula and Figs. A.4.6 -4(a) -4(d) of BS 5306/Part 2 for charts].

In calculating Reynolds number for selecting friction factors from the charts, the actual density (or specific gravity) of the foam concentrate to be used in the system shall be used. The viscosity used shall be the actual viscosity of the foam concentrate at the lowest anticipated storage temperature.

29.20.5 For purposes of computing friction loss in piping, the following "C" Factors shall be used for the Willimas and Hazens formula:

Black or Galvanized-Steel Pipe	**120**
Unlined Cast-Iron Pipe	**100**
Asbestos-Cement or Cement-Lined Cast Iron	**140**