

SINGAPORE STANDARD

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CODE OF PRACTICE FOR

**Automatic fire sprinkler
system**

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Foreword

This Code of Practice was prepared by the Technical Committee on Building Services under the purview of the Building and Construction Standards Committee (BCSC).

This code is intended to provide good guidance on design, installation, commissioning and maintenance of automatic fire sprinkler systems.

Automatic fire sprinkler systems will not be regarded as complying with these recommendations unless the installation is designed and supervised by professional engineers recognised by the relevant authority as being in this class of work.

In this revision, new clauses were added and existing ones reviewed to bring the code in line with the latest in sprinkler systems concept and technology.

The following main topics were introduced:

- a) Disallowing the use of suction lift pumps;
- b) Incorporating the special sprinkler systems, e.g. ESFR, large drop and deluge sprinkler systems;
- c) Vortex inhibitor;
- d) Remote test valve;
- e) System component fault monitoring;
- f) Location of sprinkler control valve;
- g) Protection against exposure hazard; and
- h) Full hydraulic calculations.

The following changes were made:

- a) Including more definitions;
- b) Revising the criteria of defining the limit to a single sprinkler installation to area of protection instead of number of sprinklers;
- c) Updating the list of hazard classification to follow closely to AS standards;
- d) Renaming of hazard classification;
- e) Revising the submission procedures for water services for the sprinkler systems;
- f) Removing re-cycling pre-action sprinkler system;
- g) Revising requirements of pump sets;
- h) Revising requirements for water alarm gong;
- i) Revising exemption list for non provision of sprinkler; and
- j) Increasing maximum spacing between sprinklers for ordinary hazard group.

In preparing this code, reference was made to the following publications:

- a) AS 2118: 1999 Code for automatic fire sprinkler systems
- b) AS 4118: 1996 Code for components of automatic fire sprinkler systems
- c) AS 2941: 1995 Code for fixed fire protection installation – Pumpset systems
- d) NFPA 13: 1999 Installation of sprinkler systems
- e) NFPA 20: 1999 Installation of stationary pumps for fire protection
- f) Fire Precautions for Buildings 2002

Acknowledgement is made for the use of the information from the above references.

Attention is drawn to the possibility that some of the elements of this Singapore Standard may be the subject of patent rights. SPRING Singapore shall not be held responsible for identifying any or all of such patent rights.

NOTE

1. *Singapore Standards are subject to periodic review to keep abreast of technological changes and new technical developments. The revisions of Singapore Standards are announced through the issue of either amendment slips or revised editions.*
2. *Compliance with a Singapore Standard does not exempt users from legal obligations.*

Code of practice for automatic fire sprinkler system

1 Scope

This code sets out requirements for the installation of automatic sprinkler systems in buildings. It also provides for occupancy classification.

2 Definitions

For the purpose of this code the following definitions shall apply:

2.1 Alarm valve

A non-return valve which allows the water to enter the installation and operate alarms when the installation pressure falls below the water supply pressure

2.2 Approved

Approved by the relevant authority.

2.3 Assumed area of operation

The area, i.e. the maximum number of sprinklers likely to operate, in a sprinklered building which is considered may be involved in a fire. The assumed area of operation is different in each hazard class.

2.4 Maximum area coverage for sprinkler

The area covered by each sprinkler shall be defined by lines drawn midway between adjacent sprinklers at right angles to the line joining the sprinklers and by the boundary of the area covered.

2.5 Building owner

The owner of a building or his authorised representative.

2.6 Built-up air handling plant

An air handling unit which is built in-situ within a room enclosed by insulated walls.

2.7 Combustible

- a) When applied to a material, means combustible when tested in accordance with British Standard (BS) 476: Part 4
- b) When applied to construction or a part of a building, means constructed wholly or in part of materials that are combustible.

2.8 Cut-off sprinkler (or sprinklers)

A sprinkler (or sprinklers) in a non-sprinklered building or the non-sprinklered portion of a sprinklered building immediately over the lintel of a door or window, or similar opening, in either case to provide full protection at the opening.

2.9 Density of discharge

The depth of water discharged in a given period of time.

NOTE – The density of discharge has traditionally been measured as volume per area per time. In conversion to SI units, cubic millimetres per square millimetre per minute has resulted in the unit being expressed as millimetres per minute. It is equivalent to rain gauge measurement per unit time.

2.10 Design point

A point in a sprinkler system (other than a fully hydraulically calculated system) from which the piping is hydraulically calculated back to the main stop valve.

2.11 Distribution pipes

Pipes directly feeding range pipes.

2.12 Elevated private reservoir

A reservoir situated at a higher level than the premises to be protected and under the sole control of the owner of the installation and used solely for non-potable purposes.

2.13 Encapsulated

Completely enclosed by a plastic sheet on the sides and top as applicable to pallet loads of goods or packages. Individual cartons enclosed on the top and sides with plastic and cartons waterproofed by coatings on the exterior surface are also considered to be encapsulated.

2.14 End-centre arrangement

An arrangement with range pipes on both sides of the distribution pipes (see Figure 1).

2.15 End-side arrangement

An arrangement with range pipes on one side only of the distribution pipes (see Figure 2).

2.16 Escutcheon plate

A decorative plate used to conceal the opening around the drop pipe to a sprinkler mounted below a ceiling.

2.17 Fire and draught stop

A partition of bulkhead extending from end to end and top to bottom of a concealed space, installed to delay the spread of fire, constructed from non-combustible imperforate materials which are non-shatterable under fire conditions.

NOTE 1 – Examples of acceptable fire and draught stops include the following:

- a) Structural features such as a reinforced beam or steel joist extending to or through the ceiling, and a brick wall extended up through the ceiling to the floor above.
- b) A purpose-built partition mounted on steel framework, constructed of 10 mm gypsum board, or 0.6 mm sheet steel.

NOTE 2 – Only the following apertures are permitted:

- a) Openings for the passage of individual pipes, conduits and air handling ducts, provided that such openings are reasonably close fitting.

- b) Openings not exceeding 2 m in width for the passage of groups of pipes, conduits and air conditioning ducts, protected by a 'cut-off' sprinkler or sprinklers as required to provide full protection to such openings.

2.18 Fire door

Door as defined in SS 332.

2.19 Fire protection plan

A set of updated plans approved by the authority having jurisdiction. It shall be kept at the command centre, or in the absence of a building command centre, at a place under constant surveillance.

2.20 Fire-resistance rating

The minimum period of time during which an element of a structure may be expected to function satisfactorily while subject to the standard fire test provided for in the Code of Fire Precautions for Buildings.

2.21 Gravity tank

A purpose-built water container, erected on the site of the protected premises at such an elevation as to provide the requisite pressure/flow conditions at the installation valves.

2.22 High hazard occupancy

Commercial and industrial occupancies having abnormally high fire loads:

- a) where the materials handled or processed are mainly of an extra hazardous nature likely to develop rapid and intensely burning fires ('extra high hazard – process risks'); or
- b) involving high piling of goods ('extra high hazard - high piled storage risks').

2.23 Installation

The portion of a sprinkler system downstream of, and inclusive of, the alarm valve.

2.24 Installation gauge

The gauge fitted immediately above the alarm valve to indicate the pressure in the installation.

2.25 Light hazard occupancy

Non-industrial occupancies where the amount of combustible content is low.

2.26 Listed

This shall mean equipment or materials included in a list published by a recognised institution.

2.27 Main distribution pipes

Main pipes feeding distribution piping.

2.28 Main stop valve

The valve by which all water supply to a sprinkler installation can be shut off. It is normally located immediately below the alarm valve.

2.29 Net Positive Suction Head (NPSH)

The total inlet head, plus the head corresponding to the atmospheric pressure, minus the head corresponding to the vapour pressure. NPSH, as well as inlet total head, is referred to the reference plane. It is necessary to make a distinction between:

- a) required net positive suction head (NPSHR) – a function of pump design, which may be obtained from the pump manufacturer; and
- b) available net positive suction head (NPSHA) – a function of the system in which the pump operates, which can be calculated for any installation.

2.30 Open joists and exposed common rafters

A series of members (including purlins) spaced not more than 600 mm apart, measured from centre to centre of the members.

2.31 Ordinary hazard occupancy

Commercial and industrial occupancies involving the handling, processing and storage of mainly ordinary combustible materials unlikely to develop intensely burning fires in the initial stages.

2.32 Post or box pallet

Solid or mesh box with the open face uppermost, designed to be stacked one upon the other in a self-supporting manner.

2.33 Range pipes

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

2.34 Recognised institution

An institution which undertakes the listing of equipment associated with fire fighting and safety to life and recognised by the Relevant Authority.

2.35 Relevant authority

An independent agency authorised by legislation or regulation to issue determinations, orders, or other instructions in respect of any subject covered by this code.

NOTE – Where adoption of this code is not a requirement of a relevant authority but is a requirement of a body such as an insurance company or association, then that body, or its nominees, may perform the functions of the relevant authority for the purposes of this code.

2.36 Risers (drops)

Main vertical pipes rising (or dropping) from the installation valves for linking the pipe network between floors and for linking distribution pipes with ranges (or single sprinkler if the rise or drop exceeds 300 mm in length).

2.37 Separate array

A group of sprinklers which provide protection for a relatively small area that is not part of the main protected area, and led by a separate distribution pipe.

NOTE – An example of a separate array is shown in Figure 3 downstream of design point F.

2.38 Special sprinkler

A listed sprinkler other than those specified in 2.45.

Special sprinkler are as follows:

- a) Extended coverage sprinkler. A type of spray sprinkler specifically developed to achieve an extended maximum protected area.
- b) Large drop sprinkler. A type of specific application control mode sprinkler that is capable of producing large water droplets, enabling better penetration of the fire plume and improved ability to control fires in specific high challenge risks.
- c) Early suppression fast response (ESFR) sprinkler. A type of fast response sprinkler developed to provide fire suppression in high challenge fire risks which, in many instances, eliminates the need for in-rack protection. This sprinkler has special design requirements and limitations in respect to the building structure and the system application.
- d) Extra large orifice sprinkler. A type of spray sprinkler used for high density applications such as the protection of high-piled storage where greater flows are achieved than with the standard 20 mm sprinkler at the same pressure.
- e) Enlarged orifice sprinkler. A sprinkler having a nominal 20 mm diameter orifice and a nominal 15 mm shank fitted with a metal rod extension (pintle), which is used for upgrading the density requirements of existing ordinary hazard installations.

2.39 Special sprinkler system

A system utilizing either in total, or in part, sprinkler types as listed in 3.4.3 and 7.2.2.

2.40 Sprayers

Special purposed nozzles for use in water spray systems with capabilities of extinguishments, containment or control of fires involving hazards such as flammable liquids.

2.41 Sprinkler protected area

An area of a building equipped with a sprinkler system installed in accordance with this code and separated from non-sprinkler protected areas in accordance with this code.

2.42 Sprinkler protected building

A building equipped throughout with a sprinkler system installed in accordance with this code.

2.43 Sprinkler system

A system comprising components such as valves, alarms, piping, sprinklers and water supplies designed to control a developing fire. Sprinkler system may be either standard systems or special system, and may be arranged to operate as one or a combination of the followings:

- a) Wet system. A system permanently charged with water both above and below the installation control valve (wet) (see 9.1).
- b) Dry system. A system permanently charged with air or inert gas under pressure, above the installation control valve (dry) and with water below.

- c) Pre-action system. A combination of a sprinkler system and an independent system of heat or smoke detectors installed in the same area as the sprinklers. A heat or smoke detector operates prior to the sprinklers, allowing the pre-action valve to open and water to flow into the sprinklers piping, before the first sprinkler starts to operate.
- d) Deluge system. A system of open sprinklers controlled by a quick-opening valve (deluge valve) which is operated by a system of listed heat detectors or sprinklers installed in the same areas as the open sprinklers.
- e) Tail-end system. A system essentially similar to dry, pre-action and deluge systems, with the limitation that it only forms an extension to the sprinkler system.

2.44 Standard sprinkler system

A system utilising sprinkler types as listed in 3.4.1 and 7.2.1.

2.45 Standard sprinkler

A sprinkler conforming to the thread sizes, deflector type and K factors specified in 7.3.

Standard sprinklers are as follows:

- a) Conventional sprinkler. A sprinkler designed to produce a spherical type of discharge with a proportion of water being thrown upwards to the ceiling. A conventional sprinkler is usually designed with a universal type deflector enabling the sprinkler to be used in either the upright or pendent position. Some conventional sprinklers are, however, made in two types: one suitable for use in the upright position and the other for use in the pendent position.
- b) Spray sprinkler. A sprinkler designed to produce a parabolic discharge below the plane of the deflector with little or no water being discharge upwards to wet the ceiling. A spray sprinkler is made in two types: one suitable for use in the upright position and the other for use in the pendent position.
- c) Flush sprinkler. A sprinkler designed for use with concealed piping where it is required, for reasons of appearance, to make the sprinklers inconspicuous. A flush sprinkler is installed pendent, with the base flush to the ceiling, but has an exposed heat responsive element and retracted deflectors which drop to the normal position on actuation. Flush sprinklers are normally used in hotel lobbies, dining rooms, offices, boardrooms and parts of retail stores. Flush sprinklers are not suitable for use in atmospheres that are corrosive or subject to a high dust content. Flush sprinklers utilizing chains to locate the deflector are only suitable for use with level ceilings unless specifically listed otherwise.
- d) Recessed sprinkler. A sprinkler comprising a spray sprinkler provided with a separate escutcheon housing, usually two-piece adjustable, where part of the sprinkler yoke and heat responsive element are mounted within the recessed housing.

NOTE – Escutcheon housings are used with the spray sprinkler to ensure that the response time of the heat responsive element is not unduly impeded and that the discharge spray pattern is not obstructed.
- e) Concealed sprinkler. A sprinkler comprising a spray sprinkler that is fully recessed in a concealed housing and fitted with a cover plate assembly designed to release at or before the operating temperature of the sprinkler. Concealed sprinklers provide the same unobtrusive appearance as flush sprinklers.
- f) Sidewall sprinkler. A sprinkler designed for installation along the walls of a room close to the ceiling. A sidewall sprinkler provides a one-sided (half-paraboloid) discharge pattern directed outwards with a small proportion discharging on the wall behind the sprinkler. Sidewall pattern sprinklers are not normally a substitute for conventional or spray pattern sprinklers and their use is limited to such locations as offices, entrance halls, lobbies and corridors.

A sidewall sprinkler may be used with advantage in drying tunnels and hoods over papermaking machines where condensate dripping from sprinklers and piping at the ceiling could be troublesome and also in certain other locations such as shop windows and under platforms having low headroom where sprinklers would be subject to damage.

- g) Dry pendent sprinkler. A sprinkler designed for use in portions of premises protected by a dry system where it is not practicable to install sprinklers in the upright position or on a wet system where the sprinklers may be subject to frost.

Dry pendent sprinklers are designed having either conventional or pendent spray type deflectors. Dry pendent sprinklers are manufactured integral with drop pipes of varying lengths, the valve being so placed that there is no pocket or depression where water can be trapped.

- h) Dry upright sprinkler. A sprinkler essentially the same as the dry pendent types except that an upright type deflector is incorporated. A dry upright sprinkler is designed for use in wet systems for the protection of concealed spaces subject to freezing.
- i) Fast response sprinkler. A sprinkler that has a high level of thermal sensitivity, which enables it to respond at an early stage of fire development.

2.46 Trunk main

Pipe carrying water supplies to control valves (see Figure 4).

3 Classes of sprinkler system and design data

3.1 Classes of system

Sprinkler system shall be classified on the basis of the hazard classes of occupancy and shall be designated accordingly, viz. light hazard system, ordinary hazard system and high hazard system. (see 3.2 for the classification of occupancies according to hazard class).

3.2 Classification of occupancies

3.2.1 General

The following lists provide a guide to the classification of occupancies. The listings cannot be considered to be exhaustive. Where sprinkler protection is being designed for an occupancy which is not listed, the occupancy should be related to that which could be considered to behave in a similar manner under fire conditions; however, confirmation of such classification by the relevant authority shall be obtained prior to the designing of the sprinkler system.

3.2.1.1 Occupancy classifications are as follows:

- a) Light hazard occupancies;
- b) Ordinary occupancies:
 - 1) Ordinary hazard group 1;
 - 2) Ordinary hazard group 2;
 - 3) Ordinary hazard group 3;
 - 4) Ordinary hazard group 3 special;

- c) High hazard occupancies:
 - 1) High hazard–process risks;
 - 2) High hazard–high-piled storage risks:
 - i) Category 1;
 - ii) Category 2;
 - iii) Category 3;
 - iv) Category 4.

3.2.1.2 Light hazard occupancies

Examples of light hazard occupancies are as follows:

- a) Bath (Turkish and sauna)
Boarding houses and residential sections of clubs, hotels and motels
- b) Hospitals, orphanages, homes and asylums
- c) Libraries (excluding stack rooms)
- d) Lodging houses
- e) Residential houses
- f) Medical and dental consulting rooms
Museums and art galleries (low combustible loading)
- g) Places of worships
- h) Prisons
Pumprooms
- i) Schools, colleges, universities
Sewerage works
- k) Waterworks and pumping stations

The piping and pressure/flow requirements for light hazard systems are not designed to provide adequate densities should more than six sprinklers come into operation. Therefore, where there is any undivided area in excess of 126 m² within a building otherwise classified as light hazard, the building shall be classified throughout as ordinary hazard group 1.

NOTE – Undivided areas are those enclosed between full height walls and partitions, adequate to delay the flow of hot gases until a sprinkler head is operated.

3.2.2 Ordinary hazard occupancies

3.2.3.1 Ordinary hazard group 1 (OH 1) occupancies

NOTE – OH 1 Excludes woodworking, painting and any other high fire load areas which are to be treated as ordinary hazard Group 3 occupancies. In areas where there is storage of stock within the categories described in 3.2.1.1 in excess of the storage heights set out in the note to Table 21(A) and 21(B), high hazard protection will be required. Premises having mixed occupancies must be referred to the relevant authority for a decision.

Group 1 ordinary hazard occupancies include the following:

- a) Abrasive wheel and powder manufacturers
Aerated water manufacturers (not on brewery premises)
Artificial stone manufacturers

- Asbestos and asbestos millboard manufacturers
- Assayers (gold and silver)
- b) Bacon curers
- Bead makers (gold, etc)
- Boiler composition manufacturers
- Brooch manufacturers
- c) Carborundum manufacturers
- Carvers (stone)
- Cement works
- Chrome platers
- Clubs/ Hotels/ Motels (excluding public entertainment area such as discos which may be protected as ordinary hazard group 3)
- Concrete block manufacturers
- Copper plate engravers
- Creamery and wholesale dairies
- d) Emery grinders
- Engravers
- e) Fibrous cement millboard manufacturing
- f) Galvanizing works
- Gold and silver smelters
- Grindstone manufacturers
- g) Ice factories
- Ivory turners
- h) Jewellery manufacturing and engraving factories
- i) Marble and slate works
- Mirror manufacturers
- Monumental masons
- j) Offices
- Ore grinders
- k) Plant rooms (building services only)
- NOTE – Occupancy classification of plant rooms, other than for building services, should be individually assessed.
- Plating works
- Pre-cast concrete and brick manufacturing
- Precious stone cutters
- l) Quarry buildings
- m) Restaurants and cafes
- Recreation ground and race-course stands and pavilions
- o) Salt manufacturers
- Sports pavilions and stands
- Silversmiths manufacturing
- Stained glass manufacturers
- Stone working premises
- Stucco manufacturers

3.2.3.2 Ordinary hazard group 2 (OH 2) occupancies

NOTE – OH 2 Excludes woodworking, painting and any other high fire load areas which are to be treated as ordinary hazard group 3 occupancies. In areas where there is storage of stock within the categories described in 3.2.1.1 in excess of the storage heights set out in the note to Table 21(A) and 21(B), high hazard protection will be required. Premises having mixed occupancies must be referred to the relevant authority for a decision.

Group 2 ordinary hazard occupancies include the following:

- a) Abattoirs/meat processing and boiling-down works
Aircraft engine works (excluding engine testing)
- b) Bakers and biscuit manufacturers
Bakers' sundries manufacturers
Baking powder manufacturers
Battery manufacturers (excluding stationary types with plastic housings)
- c) Cake mixture manufacturers
Carpet beaters and cleaners
Chemists works and chemists (manufacturing or analytical) not producing or using flammable solids, liquids, dusts and the like
Cinematograph film dealers and exchanges
Coffee hullers
Coal and coke dealers' premises
Coffee roasters
Condensed milk manufacturers
Confectionery manufacturers
- d) Dental material, etc, manufacturers
- e) Electric lamp and neon light manufacturers
Emery paper/cloth manufacturers
Enamellers
Engineering works
- f) Fibrous plaster, etc, modellers
Film (photographic) manufacturers
Fish curers
- g) Glasspaper and sandpaper manufacturers
Glucose manufacturers
- h) Instrument and tool manufacturers (metals)
- i) Laundries (excluding hanging garments)
- j) Motor garages, including public and private car parks
Motor vehicle manufacturers and assembly plants (excluding plastic component handling)
- k) Paint manufacturers (water-based only)
Plaster manufacturers
Pen and pencil manufacturers
Photographic supplies manufacturers
Plumbers, painters and decorators stores
Potteries
- l) Sauce, pickle and preserved food manufacturers
Shipbreakers

- m) Tea factories
Tobacco manufacturers
- n) Umbrella manufacturers
- o) Wine, spirit and beer merchants (wholesale dealers and bottlers)

3.2.3.3 Ordinary hazard group 3 occupancies

NOTE – In areas where there is storage of stock within the categories described in 3.2.1.1 in excess of the storage heights set out in the note to Table 21(A) and 21(B), high hazard protection will be required.

The following are classified as ordinary hazard group 3 occupancies:

- a) Aircraft factories (excluding hangars)
Amusement grounds
Athletic goods manufacturers (excluding plastic component handling/manufacturing)
Automatic amusement saloons
- b) Barrel stores
Basket warehouses
Bedding manufacturers (excluding foam rubber and plastics)
Bleach, dye and print works
Boathouses
Boot black and polish manufacturers
Boot and shoe factories
Bottle merchants' stores
Brake and clutch lining manufacturers
Breweries (bottling section but excluding beverage processing)
Briquette and patent fuel manufacturers
Broadcasting studios and transmitters
Brush factories
- c) Cable and telephone companies' stores
Candle manufacturers
Carbon paper manufacturers
Carpet manufacturers
Carrier and transit warehouses
Cattle food manufacturers
Christmas cracker manufacturers
Cinemas
Clothing factories
Cod liver oil manufacturers
Cork cutters and dealers
Corn, flour and provender mills
Corset manufacturers
Cotton mills (excluding preparatory processes)
Custard powder manufacturers
- d) Data processing
Departmental stores
- e) Electric cable works
Electric wire coverers
Electronic manufacturing and assembly (predominantly metal materials)
Essential oil manufacturers

- f) Felt manufacturers
Fibre goods manufacturers
Firewood cutters and dealers
Fishing net manufacturers
Fish meal manufacturers
Fish oil manufacturers
Flag manufacturers
Flax, jute and hemp mills (excluding preparatory processes)
Flour mills
Food/beverage processing
Footwear manufacturers
French polishers
Furriers
Furniture manufacturing and repairing premises (excluding foam rubber and plastics)
- g) Glass factories
Glass merchants
Glue works
Gramophone records manufacturers
Granaries, grain and seed mills
Greasy cloth, etc washers
Grease works
Grocery and provisions manufacturers
- h) Hat manufacturers
Hay and straw dealers
Hosiery factories
- i) Jute processing
- j) Lace factories
Lampshade manufacturers
Lard and fat refiners
Laundries and dry cleaner's premises
Leather goods factories
- k) Maltings and cooperages
Margarine works
Market halls
Mustard, pepper and chicory mills
Museums (with high combustible loading)
- l) Nitrates storage
- m) Oilskin manufacturers
- n) Paper goods manufacturers
Paper mills
Paper surfaces and waxers
Plastics goods manufacturers (excluding foam plastics)
Photo graphic materials works
Pharmaceutical and chemical manufacturers (not producing or using flammable solids, liquids, dust and the like)
Poultry grit and food manufacturers
Printers and allied trades (excluding flammable liquids)

- o) Rag carbonisers
Rice husking mills
Roofing felt, tarpaulin and tent manufacturers
Rope and twine manufacturing
Rubber and rubber goods manufacturers (excluding foam rubber)
- p) Sack and bag manufacturers
Sawmills and timber yards
Scenery (theatrical) stores
Seed and shale oil refiners
Shipbuilders (excluding plastic)
Shirt factories
Showrooms
Shops
Sisal factories
Spice grinders
Stables
Starch works
Stationers, booksellers and paper dealers (not waste paper)
Straw plait and straw hat manufacturers
Sugar factories and refineries
- q) Tailors' wadding manufacturers
Tanneries
Telegraph and telephone wire coverers
Telephone exchanges
Theatres, music halls and public entertainment areas
Toy and doll makers
Tram and railway sheds
Typewriter ribbon manufacturers
Tyre factories
- r) Upholsterers (excluding foam rubber and plastics)
- s) Wafer Fab
Wallpaper manufacturers
Warehouses and storage buildings (storage heights not exceeding the figures stated in the note to Table 21(A) and 21(B))
Waste paper dealers
Waterproof cloth manufacturers
Wax figure manufacturers
Woodworkers
Woollen and worsted mills (including carpet works)

3.2.3.4 Ordinary hazard group 3 special

NOTE – This group is an extension of group 3 occupancies where flash fires are likely, covering somewhat larger areas of operation, such as might be anticipated in connection with preparatory processes in textile mills and certain other risks. High hazard protection is required in areas where there is storage of stock within to categories described in 3.2.1.1 in excess of the storage heights set out in the note to Table 21(A) and 21(B).

Group 3 special ordinary occupancies include the following:

- a) Chemical works and chemists (manufacturing or analytical) producing or using flammable solids, liquids, dusts and the like
Copra kilns
Cork factories
Cotton mills (preparatory processes)

- b) Distilleries (stillhouses)
- c) Exhibitions
- d) Fiberglass products manufacturers
Film and television studios
Flax and hemp scutch mills
Flax, jute and hemp mills (preparatory processes)
- e) Match factories
- f) Oil mills (crushing and solvent extraction)
- g) Pharmaceutical and chemical manufacturers (producing or using flammable solids, liquids, dust and the like)
Printing and allied trades (using flammable inks and solvents)

3.2.4 High hazard occupancies

3.2.4.1 High hazard - process risks

Examples of high hazard process risks are as follows:

- a) Aircraft engines testing
Aircraft hangars
- b) Celluloid manufacturers and celluloid goods manufacturers
- c) Electrical/electronic manufacturing and assembly premises (predominantly plastic components)

Exhibition halls with unusually high ceiling and high concentration of combustibles
- d) Firelighter manufacturers
Fireworks manufacturers
Flammable liquid spraying
Floor cloth and linoleum manufacturers
Foam plastics and foam plastics goods manufacturers and warehouses
Foam rubber and foam rubber goods manufacturers and warehouses
- e) Paint, colour and varnish works
Plastic goods manufacturing and processing (where plastic is one of the basic materials in the operation)
- f) Resin, lamp black and turpentine manufacturers
Rubber substitute manufacturers
- g) Tar distillers
Theatrical scenery stores
- h) Vehicle repair shops
- i) Woodwool manufacturers

3.2.4.2 High hazard - high piled storage risks

The protection of high-piled storage risks depends on the method of storage, the hazardous nature of the stock, and the height of storage. Provision is made for protection where sprinklers are only provided at the roof or ceiling and also where additional sprinklers are provided at intermediate levels in the storage racks. The term "storage" includes the warehousing or the temporary depositing of goods or materials.

High piled storage risks have been subdivided according to the severity of the hazards of the stock and the classification as set out in the following paragraphs.

a) Category 1

Category 1 comprises ordinary combustible materials and non-combustible materials in combustible wrappings, excluding those items specified under category 2, 3 and 4, stored in bulk, in pallets or on racking, to heights exceeding 4 m.

NOTE – The lists of items in category 2, 3 and 4 are not exhaustive, and it should not be assumed that items of storage not specifically mentioned are regarded automatically as coming under category 1. Items listed in category 2, 3 and 4 are those of which experience has shown that the materials produce exceptionally intense fires with the high rate of heat release. Where there is any doubt about classification, confirmation should be obtained from the relevant authority.

- 1) Baled wool
- 2) Cartons containing alcoholic beverages with an alcoholic content up to and including 20% (e.g. beer and wine)
Carpets
Clothing (excluding multilevel hanging garments)
- 3) Electrical appliances (metal)
- 4) Hardboard
- 5) Glassware and crockery (in cartons)
Groceries

NOTE – This item applies only to the storage of grocery items. Packaging and other items in the storage area may require protection appropriate to a higher category.
- 6) Library stack rooms
- 7) Metal goods (in cartons)
- 8) Paints (water-based)
- 9) Textiles
- 10) All forms of paper storage other than those specified under category 2, 3 and 4.

b) Category 2

Examples of category 2 storage are as follows:

- 1) Aerosol packs with non-flammable contents or expellants
- 2) Baled cork
Baled waste paper

- 3) Cartons and carton flats
Cartons containing alcohols in cans or bottles with an alcoholic content in excess of 20% (e.g. whisky)
Cartons of canned lacquers which dry by solvent evaporation
Carpet (natural blended)
Chipboard
- 4) Fibreboard (low density softboard)
Flammable liquids in non-combustible containers
- 5) Linoleum products
- 6) Palletised whisky stocks
Plastics (non-foamed) other than celluloid
- 7) Rolled pulp and paper (horizontal storage excluding light weight)
Rolled asphalt paper (horizontal storage)
- 8) Veneer sheets
- 9) Wood patterns
Wooden furniture

c) Category 3

Examples of category 3 storage are as follows:

- 1) Bitumen coated or wax coated paper
- 2) Carpet (synthetic)
Celluloid
- 3) Electrical appliances (plastic)
Esparto (loose)
- 4) Flammable liquids (in metal containers)
Foamed plastics and foamed rubber products (with or without cartons) other than those specified in Category 4
- 5) Hanging garments (multilevel)
- 6) Paint (solvent-based, in metal containers)
Plastics (non-foamed) with or without cartons
Plastics (foamed) in cartons
- 7) Rolled pulp and paper (vertical storage and lightweight paper horizontal storage)
Rolled asphalt paper (vertical storage)
Rubber goods (excluding tyre storage)
- 8) Ventilated wood stacks
- 9) Waxed or asphalt coated paper and containers in cartons
Woodwool
Wooden pallets and wooden flats (idle)
- 10) All materials having wrappings or preformed containers of foamed plastics

d) Category 4

Examples of category 4 storage are as follows:

- 1) Foamed plastics without cartons and non-woven synthetic fibre products with or without cartons
- 2) Off-cuts and random pieces of foamed plastics or foamed rubber
- 3) Plastic pallets (idle)
- 4) Rolls of sheet foamed plastics or foamed rubber
Rolled lightweight paper (vertical storage)
Rolled non-woven synthetic fabric
- 5) Tyre storage

3.2.4.3 Storage risks requiring special consideration

Storage risks requiring special consideration would include aerosols with flammable contents storage, flammable and combustible liquid in plastic containers, vertically stored tissue paper, and the like.

NOTE 1 – Classification and form of protection may be subject to approval by the relevant authority.

NOTE 2 – Guideline as to the classification and form of protection for this type of risk may be obtained from Factory Mutual Engineering Corp. Property Loss Prevention Data Sheets, NFPA Standards or other appropriate international guidelines.

3.2.4.4 For high challenge storage occupancies, the design of automatic sprinkler system may be based entirely on NFPA standards, subject to approval by the relevant authority.

3.3 Types of sprinkler systems**3.3.1 General**

The types of sprinkler systems considered in this code are standard sprinkler systems, deluge and special sprinkler systems.

3.3.2 Standard sprinkler systems**3.3.2.1 Categories**

Standard sprinkler systems shall include the following categories:

- a) Wet pipe;
- b) Dry pipe;
- c) Wet pipe incorporating tail-end dry pipe systems;
- d) Pre-action.

3.3.2.2 Wet pipe systems

A wet pipe system is a standard sprinkler system permanently charged with water under pressure both above and below the installation alarm (wet pipe) valve (see 9.10.1).

Wet pipe systems shall be installed in premises where there is no danger at any time of the water in the pipes freezing.

Sprinklers in wet pipe systems may be installed in either the upright pendent position.

Wet pipe systems shall be so designed that the maximum floor area, (excluding concealed spaces, within machines or in similar locations which may be ignored) but including mezzanine floor areas, controlled by one control assembly, including tail-end extensions, does not exceed the following:

- a) 9000 m² for light and ordinary hazard installations.
- b) 8000 m² for high hazard installations. However, where roof protection only is provided in accordance with Table 21(B), area of storage, including aisles, protected by one installation shall not exceed 6000 m².
- c) Where single installations protect high hazard areas, with roof protection only provided in accordance with Table 21(B), and the area of the pallet racking including aisles is less than 1000 m², the total installation area may be extended to 8000 m².
- d) Where single installations protect both high hazard areas and ordinary or light hazard areas, the high hazard area shall not exceed the floor area limitations specified for that hazard and the total area shall not exceed 9000 m².
- e) Where single installations control intermediate level sprinklers in storage racks, the floor area occupied by the racks (including aisles) shall not exceed 4000 m².

3.3.2.3 Dry pipe system

A dry pipe system is a standard sprinkler system in which the system piping is permanently charged with air under pressure above the alarm (dry pipe) valve and with water under pressure below the valve.

Dry pipe systems are normally only allowed in buildings where the temperature conditions are artificially maintained close to or below freezing, such as in cool stores, fur vaults, or where the temperature is maintained above 70°C as in drying ovens. Special approval is required for dry pipe systems in other circumstances. (See special provisions in 6.10 for cold storage warehouse.)

The floor area controlled by one control assembly in a dry system shall not exceed that prescribed that in Table 1.

Table 1 – Maximum floor area for dry pipe systems

1 Condition	2 High hazard system (m ²)	3 Ordinary and/or light hazard system (m ²)
With an accelerator or exhauster (see 9.10.4)	2100	3700
Without an accelerator or exhauster	1400	2500

Sprinklers shall be installed in the upright position above the line of pipes in dry pipe systems unless approved dry pendent pattern sprinklers (see 7.2.1(g)) are installed or where standard sprinklers erected pendent have an approved anti-freezing device incorporated.

In dry systems, piping shall be arranged with slope for drainage (see 8.11).

3.3.2.4 Wet pipes incorporating tail-end dry pipe systems

These systems are essentially similar to the systems described in 3.3.2.3 except that they are of comparatively small extent and form extensions to standard sprinkler installation. Tail-end systems are subject to limitations and variations set out in 3.3.2.4 and 3.3.2.5.

The following limitations and specific requirements shall apply for tail-end installations:

- a) The total area of tail-end systems on one wet installation shall not exceed 2500 m². Any one tail-end system shall not exceed 1000 m².
- b) The subsidiary stop valve shall be monitored in accordance with 9.2.4.
- c) Suitable drainage shall be provided.
- d) Tail-end systems connected to dry installation shall be limited to dry systems.

They are permitted as extensions to a wet pipe system in comparatively small areas where the temperature conditions are artificially maintained close to or below freezing, such as in cool stores, fur vaults or where high temperature is maintained as in high temperature ovens or stores.

Sprinklers shall be installed in the upright position above the line of pipes in tail-end systems unless approved dry pendent pattern sprinklers (see 7.2.1(g)) are installed or where standard sprinklers erected pendent have an approved anti-freezing device incorporated.

To assist in the maintenance of a tail-end system when under air pressure, it is permissible to fit a subsidiary stop valve immediately beneath the tail-end valve, provided that the arrangements comply with the requirements of 9.2.4.

3.3.2.5 Tail-end anti-freezing solution systems

These systems are suitable for use in small cool rooms and freezing chambers and other areas such as loading docks and outhouses in localities subject to freezing conditions. They perform essentially the same function as the systems described in 3.3.2.4.

The following requirements shall apply for tail-end systems incorporating anti-freezing solutions:

- a) Piping within the area subject to freezing shall be fitted with anti-freezing solution and shall be arranged so as to prevent diffusion of water into that area.
- b) Anti-freezing solutions shall have a freezing point of not less than 10°C below the minimum temperature possible in the area subject to freezing. Details of the anti-freezing solution proposed shall be submitted to the relevant authority for approval.
- c) The area covered by any tail-end anti-freezing solution system shall not exceed 250m².
- d) The piping shall be arranged so that the interface between the anti-freezing solution and the water in the wet system is lower than the point of connection to the wet system.
- e) The following valves and fittings shall be incorporated in the piping (see Figure 5):
 - 1) A subsidiary stop valve monitored in accordance with 9.2.4;
 - 2) A drain valve;
 - 3) An upper test valve, neither more than 350 mm nor less than 250 mm below the filling connection in the wet system;
 - 4) A lower test valve, not less than 1.2 m below the upper test valve;
 - 5) A filling connection;
 - 6) A non-return valve. The disc of the non-return valve shall have a 1 mm hole to allow for expansion of the solution during a temperature rise and thus prevent damage to sprinklers. All valves in the system piping shall be metal-faced.

3.3.2.6 Pre-action systems

A pre-action system is a combination of a standard sprinkler system and an independent approved system of thermal or smoke detectors installed in the same areas as the sprinklers. In general, thermal or smoke detectors operate prior to sprinklers, and so a pre-action valve will open to allow water to flow into the sprinkler piping before the first sprinkler operates.

The sprinkler system piping is normally charged with air under pressure and is monitored so that an alarm is given on reduction of the air pressure.

The pre-action alarm valve controlling the water supply is operated either:

- a) solely by the approved system of detectors to allow the sprinkler piping to become charged with water thus reverting to a wet pipe system, the object being to prevent a discharge of water from piping or sprinklers that have suffered mechanical damage;
- b) by the approved system of detectors, or independently by the operation of a sprinkler releasing the air from the sprinkler piping, the object being to facilitate an earlier discharge of water from sprinklers on a dry pipe system. Operation of the sprinkler system is unaffected by any failure in the detector system; or
- c) by both the system of detectors and the operation of a sprinkler releasing the air from the sprinkler piping.

In each case the detection system also automatically operates an alarm.

The thermal or smoke detection system shall operate an approved continuously energised valve or trip mechanism to release the pre-action alarm valve when the valve or trip mechanism becomes de-energised.

The floor area controlled by one control assembly in a pre-action system shall not exceed that prescribed in 3.3.2.2.

Where the piping could be subject to freezing, sprinklers shall be installed in the upright position and the piping arranged with an adequate slope for drainage (see 8.11).

Full details of proposals for installation of pre-action systems shall be submitted for approval to the relevant authority before any erection work is commenced.

The installation and spacing of detectors shall comply with the requirements of Singapore Standard Code of Practice, CP 10.

3.3.3 Deluge system

Deluge systems are systems of open sprinklers controlled by a quick opening valve (deluge valve) which is operated by a system of approved thermal detectors or sprinklers installed in the same areas as the open sprinklers.

These systems are designed primarily for special hazards such as those listed as high hazard in Sub-3.2.4, where any fire could be anticipated to be intense with a fast rate of propagation. In these circumstances it is desirable to apply water simultaneously over a complete zone in which a fire may originate by admitting water to open sprinklers or to medium or high velocity sprayers.

Full details of proposals for installation of deluge systems shall be submitted to the relevant authority for approval before any erection work is commenced.

3.4 Design data

3.4.1 Standard sprinkler systems

Each standard sprinkler system shall be hydraulically designed in accordance with the relevant hazard class to provide an appropriate density of discharge over an assumed area of operation, i.e. number of sprinklers likely to operate, in the hydraulically most unfavourable parts of the protected building.

The design densities of discharge and the assumed area of operation for the three classes shall be as given in Table 2.

Table 2 – Design densities of discharge and assumed areas of operation for standard sprinkler systems

Class of hazard	Design density of discharge mm/min	Assumed area of operation m ²
Light	b	b
Ordinary:		
Group 1	5 ^a	72
Group 2	5 ^a	144
Group 3	5 ^a	216
Group 3 Special	5 ^a	360
High:		
Process risks	7.5 to 12.5	260
High piled storage risks	7.5 to 30	260 or 300
^a Provision is made for the density to be increased for certain areas by specifying closer spacing of sprinklers (see 10.4.1 or 11.3.1).		
^b Design criteria of light hazard group shall refer to clause 10 of this standard.		

3.4.2 Deluge systems

The piping for the open sprinklers or sprayers shall be fully hydraulically calculated as for high hazard systems (see 12.4.2.4) to ensure that the appropriate density of discharge is available from the four hydraulically most unfavourably situated sprinklers or sprayers as defined in clause 13 at each extremity of the deluge systems when all the sprinklers or sprayers in the system are discharging.

3.4.3 Special sprinkler systems

3.4.3.1 General requirements

A special sprinkler system as defined in 2.38 shall be arranged to operate as one or a combination of the following:

- a) Wet system;
- b) Dry system;
- c) Pre-action system;
- d) Tail-end system.

Special sprinkler systems shall comply with the requirements set out in 3.3.2.2 to 3.3.3 and 3.4.3.2 to 3.4.3.3.

3.4.3.2 Specific requirements

Special sprinkler systems shall be installed in accordance with the spacing, location, maximum and minimum pressure limitations, and other requirements set out in:

- a) the listing for the specific component;
- b) the manufacturer's published data sheets, and
- c) the codes and standards referenced therein.

The critical design and installation requirements for special sprinkler systems are those that directly affect the performance of the sprinklers and shall apply only to that part of each system downstream of the control assembly. Other issues, such as maximum floor area controlled by one control assembly, alarm and monitoring system, valving, pipe materials, hangers, bracing, and the like, shall conform to the requirements of this code.

All aspects relating to the design and installation of water supplies shall be in accordance with this code, with the following exceptions:

- a) For ESFR sprinkler systems, a duration of not less than 60 minutes shall apply.
- b) Where a water supply duration in excess of 90 minutes is a requirements of the manufacturer's data sheets or the codes and standards referenced therein, that duration shall apply.
- c) Where a water supply duration in excess of 90 minutes is a requirements of Factory Mutual Data Sheets nominated in this code as the basis for compliance, that duration shall apply.

The maximum area covered by a special sprinkler installation shall be in accordance with 3.3.2.2.

The design principles and operating characteristics of special sprinkler systems are often significantly different from those applicable to standard sprinkler systems. The special sprinkler may be unable to cope with some of the building features, occupancies, storage arrangements, and the like, which are commonly acceptable for standard sprinklers systems. Therefore, it is essential that the limitations of special sprinklers and special sprinkler systems be thoroughly understood and applied without exception.

3.4.3.3 Early Suppression and Fast Response (ESFR) sprinkler system

ESFR sprinkler system shall be wet systems, and shall be designed in accordance with this section, and shall only be used for nominated high-piled storage risks.

Occupancy classification and the commodities to be protected by ESFR sprinkler systems shall be in accordance with and restricted to those listed within current Factory Mutual Loss Prevention Data and NFPA standards.

ESFR sprinkler systems are designed exclusively to suppress high-challenge, high-piled storage risk warehouse fires. In many instances, in-rack sprinklers can be reduced or eliminated. The system is expected to discharge a large volume of water at a high speed, directly onto a fire to suppress the fire before it develops. ESFR sprinklers are quick-acting high performance sprinklers which have the capability of extinguishing fires within designated risks. There is no room for error in the design and installation of ESFR sprinkler systems; the design principles and the operating characteristics are significantly different from standard sprinkler protection. ESFR sprinkler systems may be unable to cope with adverse design features which may be acceptable when installing standard sprinkler protection.

4 Installation

4.1 Approval of sprinkler system

4.1.1 General

Prior to commencing erection, the professional engineer shall obtain the necessary approvals from the relevant authorities. The authorities may include that authority empowered to approve the installation of an automatic sprinkler system and Water Department, Public Utilities Board (PUB).

4.1.2 Submission

Submission shall be made to Water Department, PUB on the water service installations. Water Supply to the automatic fire sprinkler tank shall comply with the relevant requirements of the Public Utilities (Water Supply) Regulations and Singapore Standard CP 48 - Code of Practice for Water Services.

Details shall include the type of material of incoming pipes and routing of incoming pipes to the automatic fire sprinkler tank together with the cross sectional details of the automatic fire sprinkler tank.

4.1.3 Fire protection plan

A set of updated plans shall be kept at the command centre, or in the absence of a building command centre, at a place under constant surveillance.

4.2 Sprinkler-protected buildings

4.2.1 Classification as sprinkler-protected building

To be classified as a sprinkler-protected building, a building shall be sprinkler-protected throughout, other than where exceptions are permitted under 4.2.5.

4.2.2 Classification as sprinkler-protected area

Where it is proposed to protect a portion of a building only, for that portion to be classified as a sprinkler-protected area, it shall be sprinkler-protected throughout and shall be separated from non-sprinkler-protected areas by a construction having a fire-resistance rating of not less than 2 hour with the exception of those areas contained in 4.2.5.

Where the sprinkler-protected building is linked to a non-sprinkler-protected area by a roofed connection (e.g. roofed passageway, roofed ramp or tunnel), protection shall extend to a wall having a fire resistance rating of not less than 2 hour. The wall shall extend from top to bottom and side to side of the passageway, ramp or tunnel, with any door or shutter in the wall being a listed fire door or fire shutter. Where the wall is located at the junction with the non-sprinkler-protected building, the link shall be sprinkler-protected.

4.2.3 External sprinkler protection

External sprinkler protection shall be provided if required to comply with the relevant section of the Code of Fire Precautions for Buildings.

4.2.4 Protection against exposure hazard

4.2.4.1 Extent of application

Any part of an external wall, of the sprinkler-protected building, including glazed openings and roof overhangs with a fire resistance rating of less than ½ hour within 10 m of an exposure hazard, shall be protected with external sprinklers.

For the purpose of this sub-clause 'external wall' shall include the façade of raised sections of the building, such as roof lanterns, set back from the perimeter of the sprinkler-protected building; and 'exposure hazard' shall mean a source of radiant heat such as a non-sprinkler-protected building within a fire resistance rating of less than ½ hour or areas used for storage or handling of flammable or combustible materials.

4.2.4.2 Sprinklers

All sealed sprinklers used for exposure protection shall be rated as fast response type and shall have a temperature rating of 93°C.

Sprinklers shall be any of the following types and orientation:

- a) Spray (SP) – mounted horizontally with the deflector towards the window or wall;
- b) Upright Spray (SU) – mounted horizontally with the deflector away from the window or wall;
- c) Pendent Sidewall (WP) – mounted pendent and oriented to direct the spray towards the window or wall.

Sprinklers specially designed for the purpose and located and spaced in accordance with their listing.

Conventional sprinklers (CU/P) shall not be used, except in the case of protection beneath roof overhangs. Sprinklers beneath roof overhangs shall not be considered a substitute for protection of walls.

4.2.4.3 Shielding

Where building features do not shield sprinklers to prevent cooling from sprinklers operating above, such sprinklers shall be fitted with metal shields not less than 80 mm diameter.

4.2.4.4 Sprinkler spacing and location

Unless specifically listed otherwise, sprinklers shall be located in accordance with the following table.

Distance	Position	Maximum	Minimum	Point of measurement
Distance between sprinklers	Horizontally	2.5 m	1.8m ^a	Centre of sprinkler
	Vertically	4.0 m	NA	Deflector to deflector
Horizontal distance from wall	Horizontal sprinkler	100 mm	20 mm	Sprinkler deflector
	Pendent sprinkler	300 mm	10 mm	Centre of sprinkler
Vertical distance below top of protected surface	Horizontal sprinkler	100 mm	50 mm	Centre of sprinkler
	Pendent sprinkler	100 mm	50 mm	Sprinkler deflector

^a The 1.8 m minimum distance may be reduced where sprinklers are separated by a baffle or building feature which will prevent cooling from an adjacent operating sprinkler.

In addition to the requirements contained in the above table, a sprinkler shall be positioned not more than 1.25 m horizontally from:

- a) the vertical extremities of the protected surface;
- b) the vertical extremities of each glazed opening, with the sprinkler located within the opening; and

- c) the centre of any building feature such as downpipes and glazing bars or mullions, which project more than 40 mm from the protected surface.

Where vertical glazing bars or mullions project more than 40 mm from the glazed surface and are spaced not more than 1660 mm centre to centre, every alternate sprinkler may be positioned on the centre-line of a mullion or glazing bar, except that sprinklers shall be positioned within 1.25 m of each side of any vertical glazing bar or mullion that exceeds 40 mm in width.

4.2.4.5 Piping

External sprinklers shall be fed either individually by range pipes or as groups by dedicated distribution pipes connected to a distribution pipe of internal sprinkler system. Pipes sizes shall be determined by full hydraulic calculation methods.

4.2.4.6 Performance

Sprinkler systems that incorporate exposure protection shall be fully hydraulically designed so that the flow from any external sprinkler shall be not less than 75 L/min when the required maximum number of external sprinklers are operating.

Where the area to be protected by an individual sprinkler is less than 2.5 m wide, the flow rate may be reduced proportionally subject to a minimum end head pressure of 70 Kpa.

The required number of sprinklers assumed to be in simultaneous operation shall be the number of sprinklers opposed to each exposure hazard, up to a maximum of 18.

Hydraulic calculation methods shall conform to the requirements of this code, as appropriate.

4.2.4.7 Water supply

If the maximum calculated demand of the exposure protection is in excess of that required for the internal sprinklers alone, the water supply shall be increased to cover the excess.

4.2.5 Permitted exceptions

The permitted exceptions shall be as follows:

- a) Non-combustible stairways, enclosed by walls and ceilings with a minimum fire resistance rating of 2 hour and having all openings fitted with fire doors and cut off sprinklers.

NOTE – A stairway constructed as above, but having a ceiling over the top landing with a fire-resistance rating of less than 2 hour, need only have sprinkler protection to such ceiling.
- b) Toilets and washrooms, but not cloakrooms, separated from the sprinklered building by walls, floors and ceilings with a fire-resistance rating of not less than 2 hour, with all openings to the sprinklered building fitted with fire doors or approved fire shutters with a minimum fire resistance rating of 1/2 hour and cut-off sprinklers.
- c) Hosereel compartment with height less than 1.5 m and area not more than 1 m².
- d) Rooms or compartments containing dry electric equipment other than computer areas, used for no other purposes, enclosed by walls, floors and ceilings with a minimum fire resistance rating of 2 hour, and with all openings to the sprinklered building fitted with fire doors or approved fire shutters with a minimum fire-resistance rating of 2 hour. Such room or compartment shall be fitted with a detection and alarm system installed in accordance with the requirements of Singapore Standard CP 10.
- e) Silos or bins for the storage of grain inside buildings forming part of corn mill, distillery, maltings or oil mill premises.
- f) Ovens, hovels and kilns in potteries, including earthenware, brick, tile and glass works.

- g) The undersides of screens or shields erected over the wet ends of papermaking machines.
- h) Over salt baths and metal melt pans where the application of water would endanger personnel. Piping and sprinklers may be located over such places if a suitable canopy is fitted.
- i) Over potable water storage wherever there is a danger of contamination of that water storage in the event of sprinkler operation.
- j) Unroofed docks or loading platforms, subject to the requirements of 6.6.13.
- k) A building communicating with a sprinklered building through a stairway constructed of non-combustible material and enclosed by walls and ceilings with a minimum fire resistance rating of 2 hour, all openings there from being protected by fire doors.

4.3 Transmission of alarm signal to fire service

Unless otherwise approved, provision shall be made for the automatic transmission of a distinctive alarm signal to the relevant authority receiving centre or any other receiving centres as may be approved by relevant authority on the actuation of the fire sprinkler system.

Where this provision is made, the following requirements shall be observed (see also 9.10):

- a) If at any time the connection to the relevant authority is severed, attention shall be drawn to this fact at the receiving centre.
- b) A notice shall be located in close proximity to the control valves to indicate that there is a direct alarm connection to the relevant authority.
- c) The system wiring and power supply shall comply with the requirements of Singapore standards CP 10 and CP 5.
- d) For alarm transmission purposes, the control assemblies of not more than four installations may be grouped, provided that each installation is fitted with an approved mechanical indicating device which, when actuated, remains in the 'system operated' position until manually reset. In addition, a readily discernible sign shall be located adjacent to the control assemblies to indicate the zone controlled by each set of control assemblies.

4.4 Local alarm

Every installation shall be fitted with an externally mounted approved water motor alarm, except that where alarm valves are grouped one water motor alarm may serve all installations in any one location. The water motor alarm shall be located as near as practicable to the alarm valve(s) (see also 9.13).

4.5 System component fault monitoring

4.5.1 General

Fault monitoring of system components shall be provided in accordance with 4.5.2 to 4.5.5.

4.5.2 Monitoring devices

4.5.2.1 General

Class A monitoring devices shall be installed in all cases except that class B devices are permitted where the monitored components are located within a secure area or room with access restricted by means of security devices or a system providing at least the same level of security as achieved with class A monitoring.

4.5.2.2 Class A monitoring devices

Class A monitoring shall transmit a signal upon:

- a) a change of status of the monitored component;
- b) any attempt to tamper with or bypass the monitoring device; and
- c) any attempt to tamper with or bypass the connection back to the receiving center.

4.5.2.3 Class B monitoring devices

Class B monitoring shall transmit a signal upon:

- a) a change of status of the monitored component; and
- b) any attempt to tamper with or bypass the connection back to the receiving center.

4.5.3 Systems to be monitored

Continuous system monitoring shall be installed:

- a) in systems containing high hazard portions greater than 300 m²;
- b) in buildings greater than 25 m effective height; and
- c) where required by acts or regulations.

4.5.4 Components to be monitored

The following components shall be monitored:

- a) Water supply stop valves excluding underground key-operated valves;
- b) Main stop valves;
- c) Subsidiary stop valves;
- d) Power supply for each electric-motor driven pump;
- e) Controller 'ready to start condition' battery voltage and fuel level for each compression-ignition driven pump.

4.5.5 Installation

Control and power supply equipment shall comply with the requirements of acceptable Code of Practice.

Fault signals from monitored components shall be connected to:

- a) a fire brigade receiving center; or
- b) a central station, including a monitoring service; or
- c) a constantly attended in-house security facility, such as the Fire Command Centre or in its absence, near the main fire alarm panel.

Should the connection be severed, attention shall be drawn to this fact at the receiving station.

4.6 Maintenance

The system shall be tested and maintained in satisfactory working order in accordance with the requirements in Annex C.

5 Water supplies

5.1 General

The water supply shall have a pressure and flow characteristic not less than those specified in 10.2, 11.2 or 12.2 as appropriate. It shall be automatic and thoroughly reliable and shall not be subject to either freezing or drought conditions that could seriously deplete the supply.

Sprinkler systems under separate ownership shall not share private water supplies nor shall they share connections to public water supplies.

Sprinkler system piping (with the exception of water supply connections to PUB mains) shall not traverse ground that is not under the control of the owner.

The water shall be fresh and free from fibrous or other matter in suspension liable to cause accumulations in the piping system.

NOTE 1 – Water supplies, other than that part under the control of Water Department PUB, should be under the control of the occupier of the building containing the installation.

NOTE 2 – In special circumstances where there is no suitable fresh water source available, consideration may be given to the use of salt or brackish water, provided that the installation is normally charged with fresh water.

NOTE 3 – Where there is a ring main or loop within the premises it is desirable to provide isolating stop valves, so situated as to maintain the maximum possible service in the event of fracture or, if it is necessary, to close down part of the ring main.

5.1.1 Additives

Corrosive chemicals such as sodium silicate (or derivatives of sodium silicate) brine, or other chemicals shall not be used while hydrostatically testing systems, for stopping leaks, or for any other purpose.

5.1.2 Acceptable sources of supply

The following sources of supply shall be acceptable:

- a) Elevated private reservoirs (see 5.9.2);
- b) Gravity tanks (see 5.9.3);
- c) Automatic pumps (see 5.10):
 - 1) drawing from suction tanks or natural sources such as rivers, lakes or underground water supply subject to the conditions laid down in 5.1; or
 - 2) boosting supplies such as elevated private reservoirs.

5.2 Water supplies

Water supplies for automatic sprinklers systems shall be of high reliability and shall be in accordance with the following requirements:

- a) Elevated private reservoir or gravity tank (compartmentalised) (see Figure 7(a));
- b) Automatic pump supply drawing from a pump suction tank (see Figure 7(b));
- c) Automatic pump supply drawing from a virtually inexhaustible source such as a river, canal, lake or sea (see Figure 7(c));

NOTE – subject to approval of the relevant authority.

- d) Automatic (booster) pump supply drawing from an elevated private reservoir (see Figure 7(d)).

In arrangements (b), (c) and (d), the automatic pump supply shall comprise one of the following:

- a) two automatic pumps, one of which shall have a compression-ignition engine drive and each shall be capable of providing independently the necessary flows and pressures for the respective hazard class (see 10.2, 11.2 or 12.2); or
- b) three automatic pumps, two of which shall have compression-ignition engine drives and any two shall be capable of providing in the aggregate the necessary pressures and flows for the respective hazard class (see 10.2, 11.2 or 12.2).

In each case the pumps shall be capable of operating in parallel, i.e. they shall have similar pressure/flow characteristics.

NOTE – Where two completely independent electric power sources are available (neither linked with the other) or where automatic change-over facilities exist between two completely independent electric power sources, the provision of two electrically driven pumps will be permitted, one supplied from each source in the former case or both supplied from one of the pumps may be regarded as being compression-ignition engine driven for the purpose of interpretation of this code.

5.4 Connections to other services

5.4.1 General

The water supply to a sprinkler system shall be separate with no other connections.

5.4.2 Fire hose reel connections

5.4.2.1 General

Connections to sprinkler system water supplies are permitted for fire hose reels, provided that the appropriate requirements of 5.4.2.2 are complied with. Such connections shall not exceed 50 mm internal diameter and shall be provided with a stop valve suitably labelled and in close proximity to the point of connection with the supply pipe.

5.4.2.2 Elevated private reservoirs, gravity tanks and automatic pumps

Connections to supply fire hose reels may be made on the supply side of the sprinkler system main stop valve.

5.4.3 Sprinkler breeching inlet

Sprinkler systems shall be provided with a sprinkler breeching inlet to enable the fire service to pump water into the system.

The breeching inlet shall be:

- a) 2-way where the supply pipe is ≤ 100 mm diameter;

- b) 4-way where the supply pipe is > 100 mm diameter and connected to:
- 1) the supply side of the control valve concerned where the highest sprinkler is ≤ 60 m above ground;
 - 2) the suction tank (which is used solely for fire-fighting purposes) where the highest sprinkler is 60 m above ground.

Sprinkler breeching inlet shall be adequately supported and located outside the building within 18 m of the fire engine access road. They shall be fitted with a full way non-return valve, any other fittings required by the water supply authority, and approved hose connections equipped with standard caps.

The pipe between the non-return valve and the outside hose connection shall be fitted with a plug-cock which shall drain to a suitable place.

The enclosure in which the fire service breeching inlet is housed shall be marked with the words '**SPRINKLER BREECHING INLET**' in letters not less than 50 mm high and shall be marked with the maximum allowable inlet pressure at that connection. If the connection does not serve the complete sprinkler system, it shall be clearly marked to indicate that part of the system which it serves.

5.5 Pressure and flow requirements

The required running pressure and flow requirements shall be as specified for the appropriate hazard class in 10.2, 11.2 or 12.2. The running pressure shall be measured on the installation gauge immediately above the alarm valve.

The static pressure equivalent (in kilopascals) of the height of the highest sprinkler above the level of the installation gauge shall be taken as $9.79 \times$ height of sprinkler above gauge

5.6 Pressure considerations

Where the water pressures applied to any system are excessive, as in the case of storeyed buildings in excess of 75 m in height, the system shall be divided into 'stages' so that the pressure on any sprinkler head does not exceed 10 bar. The 'pressure' stage shall not exceed 75 m in height. Care shall be taken to ensure that all piping, pumps, valves and fittings are suitable for the pressures that are applied. For the purpose of this sub-clause, pressure calculations shall include allowance for anticipated maximum water supply pressures, such as pressure fluctuation in pumps operating in a closed system condition.

5.7 Minimum capacity of stored water supplies

The minimum capacities specified in the relevant sub-clauses relate to stored water sources reserved for the sprinkler system, including fire hose reels if permitted.

Sub-clauses relating to minimum capacity of stored water supplies are as follows:

- a) Pump suction tanks - 5.8, 10.2.2, 11.2.2.2 and 12.2.2.2.
- b) Other - 11.2.2.1 and 12.2.2.1.

5.8 Pump suction tanks

5.8.1 General

The effective capacity of a suction or water storage tank for the sole purpose of feeding the sprinkler system shall be determined to be between the normal water level in the tank and the low water level X as defined in Figure 8. The values of dimension 'A' and 'B' in Figure 8 appropriate to the particular suction pipe sizes or determining level X shall be taken from Table 3. Where an approved and listed vortex inhibitor is installed, dimension 'A' may be ignored.

Table 3 – Appropriate suction pipe sizes

Nominal diameter of suction pipe mm	Dimension A mm	Dimension B mm
65	250	80
80	310	80
100	370	100
150	500	100
200	620	150
250	750	150
300	900	200
350	1050	250
400	1200	300

Pump suction tanks shall be of non-combustible construction.

The tank shall be compartmentalised into two separate water-tight sections connected by a valve, normally kept opened, to permit tank maintenance without interruption to the water supply.

Nevertheless, when more than one water tank is provided to store the required amount of water, tank compartmentation is not necessary provided the tanks are interconnected with isolating valves which are secured open.

Each tank or tank compartment shall be provided with an overflow pipe having an internal diameter greater than that of the inlet pipe or 100 mm in diameter, whichever is greater. The overflow pipe shall be adequately supported, and extended to discharge openly within 150 mm of a suitable drain beyond nearby pumps or other equipment. The overflow pipe shall be so positioned such that it is lower than the inlet pipe by not less than the diameter of the overflow pipe.

A drain of at least 100 mm size and controlled by a gate valve shall be provided for each tank or compartment.

A visual level indicator shall be fitted to show the depth of water in each tank or compartment.

A substantial permanent gooseneck ladder extending a sufficient distance above the top of the tank shall be provided to permit easy access.

Pump suction tanks shall have an effective capacity not less than that specified in 10.2.2, 11.2.2.2 or 12.2.2.2. If there is an automatic inflow which can be relied upon at all times, a smaller capacity may be permitted, provided that the rate of inflow enables the pump to operate at full capacity for not less than the period necessary to comply with the relevant requirements of 10.2.2 or Table 15 or Table 23.

The water supply to suction tanks shall be capable of completely re-filling the tank within the following times:

- a) capacity less than 500 m³ – to be refilled in 6 h
- b) larger capacities – to be filled in 24 h.

If the rate of input to a tank of less than 500 m³ capacity is such that it will take longer than 6 h to refill, the capacity of the tank shall be increased beyond the relevant requirements of 10.2.2 or Table 15 or Table 23. Such increase in capacity shall be sufficient to ensure that the required minimum capacity shall be available 6 hr after the volume equal to the required minimum capacity has been drained.

Provision shall be made at the point where the supply water enters the tank for suitable baffles to ensure the minimum entrainment of air.

5.8.2 Effective capacity

When calculating the effective capacity of a pump suction tank, the depth shall be taken as the measurement between the normal water level in the tank and the low water level X shown in Figure 8. Low water level X is calculated to be the lowest level before a vortex is created causing the pump to draw air (see note).

Where the suction pipe is taken from the side of the tank as shown in Figure 8(b), the clearance between the base of the tank and the lowest level of the pump suction pipe shall be not less than dimension B in the figure (see note).

Where a sump is formed in the base of a suction tank from which the suction pipe draws water, the sump shall not be smaller than indicated in Figure 8 in which the position of the sump is shown with broken lines. In addition, the sump width shall be not less than 3.6D, where D is the nominal diameter of the suction pipe. The point of entry of water to the suction pipe shall be located centrally across the width of the sump (see note).

NOTE – Where an approved vortex inhibitor is installed the following may be applied:

- Dimension A may be disregarded and low water level X may be taken as the level at which vortexing commences.
- Dimension B may be taken from the base of the tank to the level at which vortexing commences in the case of example (a). Example (b) is unlikely to be appropriate to arrangements employing a vortex inhibitor.
- Where a vortex inhibitor, in the form of a flat circular plate at the suction inlet, is used, it shall be designed as shown in Figure 9 and to the following formulae:

$$H_m = 0.5d \text{ where } d > \text{DN } 150 \\ \text{or } 0.75d \text{ where } d \leq \text{DN } 150$$

$$D = \frac{Q \times 17.68}{H_a}$$

where:

H_m	=	minimum clearance under plate, in millimetres;
H_a	=	actual clearance under plate, in millimetres;
d	=	nominal diameter of suction pipe;
D	=	minimum diameter of plate, in millimetres;
Q	=	maximum flow rate (intersection of square law curve and effective pump curve) L/min.

The plate shall not be less than 10 mm thick and shall be effectively protected from corrosion.

5.8.3 Supply from inexhaustible source

5.8.3.1 General

Where the suction pipe draws from a suction chamber fed from a virtually inexhaustible source such as a river, channel, lake, or the like, the design and dimensions specified in Figure 10 shall apply.

5.8.3.2 Slope of inlet pipes, conduits and beds of open-topped channels shall have a continuous slope towards the jackwell or suction pit of at least 1 : 125.

5.8.3.3 Diameters of pipes

The diameters of feed pipes or conduit shall be determined from the following formula:

$$D = 21.68Q^{0.357}$$

where:

- D = internal diameter, in millimetres;
- Q = maximum flow output of the pump, i.e. the nominal rating for light or ordinary hazard and the maximum design flow rate for high hazard, in litres per minute.

5.8.3.4 Depth of inlet

The top of the pipe or conduit inlet shall be not less than one diameter below the lowest known water level.

5.8.3.5 Depth of water

The depth *d* of water in open channels or weirs, and above the weir between the settling chamber and suction chamber shall be not less than that shown in the following table for the corresponding width *W* and the maximum flow output of the pump *Q*. Each suction inlet shall be provided with a separate suction and settling chamber.

The total depth of open channels and weirs shall be sufficient to accommodate the highest known water level of the water source.

Table 4 – Minimum depth of water and width of open channels and weirs for corresponding inflows

Depth <i>d</i> , mm					
250		500		1000	
Width <i>W</i> mm	<i>Q</i> max	Width <i>W</i> mm	<i>Q</i> max	Width <i>W</i> mm	<i>Q</i> max
88	280	82	522	78	993
125	497	112	891	106	1 687
167	807	143	1 383	134	2 593
215	1 197	176	1 960	163	3 631
307	2 064	235	3 159	210	5 647
334	2 342	250	3 506	223	6 255
410	3 157	291	4 482	254	7 825
500	4 185	334	5 592	286	9 577
564	4 953	361	6 340	306	10 749
750	7 261	429	8 307	353	13 670
1 113	12 054	527	11 415	417	18 066
1 167	12 792	539	11 816	425	18 635
1 500	17 379	600	13 903	462	21 411
2 000	24 395	667	16 271	500	24 395
4 500	60 302	819	21 949	581	31 142
		1 000	29 173	667	38 916
				2 000	203 320

5.8.3.6 Dimensions of suction and settling chambers (see Figure 10)

The dimension of the suction chamber and the location of suction pipes from the walls of the chamber, their depth below the lowest known water level and clearance from the bottom shall comply with the requirements of 5.8.2.

The settling chamber shall have the same width and depth as the suction chamber and a length not less than $4.4 \sqrt{H}$ where H is the depth of the settling chamber.

5.8.3.7 Inlet screens

a) Pipe or conduit

The inlet to a pipe or conduit feeding the settling chamber shall be fitted with a strainer with an aggregate clear opening not less than five times the cross sectional area of the pipe or conduit. Individual openings in the strainer shall not allow a 25 mm diameter sphere to pass through. Provision shall be made for removal of the strainer for cleaning.

b) Weir or open-top channels

Weirs and open-top channels shall be fitted with a removable screen of wire mesh or perforated metal plate with an aggregate clear opening below water level of 150 mm^2 for each litre per minute of the maximum flow output of the pump Q. The screen shall be of sufficient strength to withstand the force applied by the water should it become obstructed.

NOTE – Provision shall be made for isolation of the settling chamber for periodical cleaning and maintenance.

c) Suction inlet drawing direct from source

Where the suction inlet draws direct from the source, a walled area not smaller than that required for suction chambers (5.8.3.6) shall be provided. Where the wall extends above the surface of the water, apertures shall be provided and fitted with screens complying with the requirements of 5.8.3.7(b). Where the top of the wall is below the surface of the water level, a screen shall be fitted between the top of the wall and the highest known water level. Such screens shall provide an area not less than that required in 5.8.3.7(b) at the lowest known water level.

Provision shall be made for access to the screens for cleaning.

d) Excavated pits

Where the bed of a lake, etc is excavated to provide sufficient depth for a pump suction inlet, an area not less than that required in 5.8.3.7 (b) shall be enclosed with a screen. The largest screen area possible should be provided.

NOTE – The excavation of the bed of a lake, etc for this purpose is not recommended.

5.9 Water supplies from private reservoirs and gravity tanks

5.9.1 General

Elevated private reservoirs, gravity tanks, and pump suction tanks shall be covered in at the top in such a manner as to exclude daylight and solid matter.

Each tank or tank compartment shall be provided with an overflow pipe having an internal diameter greater than that of the inlet pipe or 100 mm in diameter, whichever is greater. The overflow pipe shall be adequately supported, and extended to discharge openly within 150 mm of a suitable drain beyond nearby pumps or other equipment. This overflow pipe shall be so positioned such that K is lower than the inlet pipe by not less than the diameter of the overflow pipe.

Each storage tank shall be fitted with a device to indicate the depth of water.

A permanent ladder or stairway, complying with the requirements of the relevant authority, shall be provided to permit access to the top of the tank.

The water in the tank shall be kept clean and free from sediment.

5.9.2 Elevated private reservoirs

Where an elevated private reservoir serves other than the sprinkler installation, there shall be a constant capacity of at least:

- a) for light hazard class - 500 m³;
- b) for ordinary hazard class - 1000 m³;
- c) for high hazard class - 1000 m³ plus the stored capacity specified in 12.2.2.

Pressure and flow tests to establish the adequacy of water supply to the sprinkler system demand for other purposes is at its peak.

The outlet from the reservoir shall be kept clean and free of debris.

5.9.3 Gravity tanks

A gravity tank shall comply with the following requirements:

- a) The gravity tank shall have a capacity in accordance with 5.7.

NOTE – Should the capacity of the tank exceed the requirement of 5.7, it is permissible to draw upon the surplus for other purposes by means of an outlet pipe on the side of the tank above the level of the quantity to be reserved for the sprinkler installation.

- b) The quantity of water required for the sprinkler installation shall be automatically maintained. If the tank forms the sole supply to the sprinkler system, the supply to the tank shall be capable of refilling the tank to the capacity required under 5.7 within 6 hr. If the rate of input of the supply to the tank is less than that required to refill it within 6 hr, the capacity of the tank will be increased by the amount of the shortfall.

5.10 Pump installations

5.10.1 General requirements

Pump installations shall comply with the following requirements:

- a) Compression-ignition engine driven pumps shall be housed in a sprinkler-protected building and shall be installed in readily accessible positions in non-combustible and fire resisting rooms used for such exclusive purposes.

Electric motor driven pumps shall be housed in:

- 1) a sprinkler-protected building and shall be installed in readily accessible positions in non-combustible and fire-resisting rooms used for such exclusive purposes; and
 - 2) a separate building of non-combustible construction that shall be used for no other purpose than for the housing of fire protection water supplies.
- b) Pump sets shall be adequately protected against mechanical damage.

- c) Separate pumps shall be provided for hydrant installations.

NOTE – The relevant authority may waive this requirement where special circumstances apply.

- d) The pump room shall be provided with adequate ventilation and lighting and equipped with standby emergency power supply.
- e) Pumps and prime-movers shall be mounted on concrete plinths at least 150 mm above the floor. All associated equipment shall be mounted at least 150 mm above the floor.
- f) Where a pump house, which is required to be sprinkler-protected, is situated remote from the sprinkler-protected premises such that it is impracticable to supply the pump house sprinklers from the installation control valves, the pump house sprinklers may be supplied from a point on the downstream side of the non-return valve on the supply pipe from the pump.
- g) The sprinkler supply connection shall be provided with a controlling stop valve locked in the open position fitted on the supply pipe to the sprinklers together with an approved alarm device with visible and audible indication of the operation of sprinklers provided at some suitable location, e.g. in the building command centre or at the installation control valves. A 15 mm drain valve shall be provided downstream of the flow alarm to permit a practical test of the alarm (where practicable, this alarm should also be connected to the Fire Service).
- h) Means shall be provided to allow a continuous flow of water through the pump at a sufficient rate to prevent overheating of the pump when it is churning.
- i) Where compression-ignition engine drives are used, a suitably sized relief valve, set to prevent over pressurising the system piping, shall be installed between the pump and the pump discharge check valve.
- j) A stop valve, padlocked in the open position, shall be fitted in the suction pipe to permit removal of the pump without draining water from the supply.
- k) The piping between the supply and the pump shall not exceed 30 m, each elbow or bend counting as 3 m of pipe. The piping shall be laid either horizontal or with a continuous rise towards the pump to avoid the possibility of air locks. A fall towards the pump is permitted for pumps under 'positive head' conditions provided that no air can be trapped in the pump suction pipe.

5.10.2 Pump operating conditions

Centrifugal pumps, where drawing from a suction tank, shall be considered to be under positive head conditions when not more than 2 m depth or one-third of the effective capacity of the stored water supply, whichever is the lesser quantity of water, is contained between the centreline of the pump and the low water level X (see 5.8.2), and shall be considered to be under suction lift conditions when located higher.

Where pumps draw from natural unlimited water supplies, such as rivers, canals, and lakes, they shall be considered to be under positive head conditions when the centreline of the pump is located not less than 850 mm below the lowest known water level and shall be considered to be under suction lift conditions when the centreline of the pump is above this level.

5.10.3 Pumps installed under positive head conditions

Where pumps are installed under positive head conditions as defined in 5.10.2, the following conditions shall be observed:

- a) The size of the suction pipe shall comply with 10.2.3.3, 11.2.3.4 or 12.2.3.3 as appropriate.

- b) Where more than one pump is provided, the suction pipes may only be interconnected if each individual pump suction inlet and each such pipe connection to the tank or tanks is fitted with a stop valve. The cross-connection pipe shall be equal in diameter to the individual pump suction pipes.

NOTE – Any interconnected pump which is out of commission is to be isolated from the system by closing the inlet suction valve and anti-overheating circulating pipe valve. Provision is to be made to automatically prevent any operating pump from drawing air from any non-operating interconnected pump through:

- 1) the pump air vent pipes;
 - 2) the pressure relief valve piping; and
 - 3) the pump anti-overheating circulating pipe.
- c) The position of the point of entry to the suction pipe shall conform to the dimensions given in Figure 8.

5.10.4 Performance requirements for pumps

Pumpsets shall be capable of satisfying the flow and pressure requirements of any assumed areas of operation in the system under consideration, calculated at the lowest available suction pressure.

NOTE 1 – When selecting a pump, margin should be allowed for deterioration of at least 50 kPa in pump performance at system design flow.

NOTE 2 – Each pump driver shall be capable of meeting the power requirements of AS 2941.

NOTE 3 – Pumps drawing from pump suction tanks shall have performance characteristics complying with the requirements given in Table 5.

Table 5 – Performance characteristics for automatic pumps drawing from pump suction tanks

1 Occupancy group	2 Sprinkler height ^a m	3 Nominal rating ^b		5 Minimum characteristics		6
		Pressure kPa	Flow L/min	Pressure kPa ^c	Flow L/min	
Light	15	180	680	320	400	
				370	225	
	30	260	800	470	400	
				520	225	
	45	340	900	620	400	
				670	225	
	60	410	1000	770	400	
				820	225	
	75	480	1100	920	400	
Ordinary Group 1				970	225	
	15	120	900	220	540	
				250	375	
	30	190	1150	370	540	
				400	375	
	45	260	1340	520	540	
				550	375	
	60	330	1500	670	540	
				700	375	
	75	400	1650	820	540	
				850	375	
Ordinary Group 2	15	130	1700	250	1000	
				290	725	
	30	200	2050	400	1000	
				440	725	
	45	260	2350	550	1000	
				590	725	
	60	320	2650	700	1000	
				740	725	
	75	380	2900	850	1000	
				890	725	
Ordinary Group 3	15	140	2250	290	1350	
				320	1100	
	30	200	2700	440	1350	
				470	1100	
	45	250	3100	590	1350	
				620	1100	
	60	320	3400	740	1350	
				770	1100	
	75	380	3700	890	1350	
				920	1100	
Ordinary Group 3 Special	15	190	2650	300	2100	
				350	1800	
	30	240	3050	450	2100	
				500	1800	
	45	310	3400	600	2100	
				650	1800	
	60	370	3750	750	2100	
				800	1800	
	75	430	4050	900	2100	
				950	1800	

^a Height of highest sprinkler above pump.^b Pump (including any orifice plates) must comply with the nominal rating within limit of ± 5 percent on flow at tie stated pressure.^c Plus friction loss between pump and control valves.

For systems where sprinkler height exceeds those given in Table 5, pumps shall be subject to approval of the relevant authority. Details shall show that the pressure/ flow characteristics of the pump adequately satisfy the requirements of 10.2.1 or 11.2.1, as appropriate.

The closed outlet valve pressure under installed conditions shall not exceed 10 bar except as provided for in 5.6. In the matching of pump characteristics with the required characteristic curve, allowance shall be made for increase in pressure at zero flow due to increase of shaft speed of the prime mover, and for increase or decrease in pressure due to positive or negative pressure at the pump suction flange.

5.11 Pump sets

5.11.1 General

Automatic pumps for use in sprinkler systems shall be listed by a recognised institution. Pump sets shall comply with the following requirements:

- a) The pump shall have a direct drive and the coupling between the pump and the driver shall allow each to be removed without disturbing the other. The pump shall start automatically. It shall be fully operational within 30 s from receipt of a signal to start. Once started, the pump shall run continuously until it is stopped manually.
- b) Each pump shall be provided with a plate giving the pump impeller diameter and the output pressure at zero suction lift at the nominal or maximum flow rating. Where the performance characteristic is achieved with an orifice plate not integral with the pump delivery, the pump name plate shall carry a reference to the fact that the performance given is that of the pump and orifice plate combination and reference shall be made to the orifice K factor, i.e.

$$K = Q/\sqrt{P}$$

where:

Q = rate of flow, in litres per minute;

P = pressure drop across the orifice, in kilopascals.

- c) For the particular pump, a separate permanent plate shall be provided giving:
 - 1) net discharge pressure at zero flow;
 - 2) net discharge pressure at the minimum and maximum flow rates required under 5.10.4;
 - 3) maximum power absorbed at rated speed at any flow rate up to the maximum flow rate required under 5.10.4; and
 - 4) rated speed.

These readings should be those taken during the pump test.

- d) The orifice plate shall comply with the requirements of 8.14. A pressure gauge shall be provided downstream of the pump outlet back-pressure valve. There shall be a test valve and pipe connection coupled to the pump delivery branch downstream of the back-pressure valve, including an orifice plate if necessary, to facilitate a running pressure test on the pump at approximately the full load condition when the test valve is fully open. Alternatively, an approved direct-reading flow meter may be used to test the pump.
- e) Where the pump draws its water from a sump, care should be taken to avoid aeration of the water during testing. Where it is impracticable to dispose of the water discharged under a full load test condition, details of the facilities available shall be submitted to the relevant authority.

- f) Each pump shall be provided with a control panel. Each pump starting device shall be actuated by a separate pressure sensor located in the installation or trunk main and set to operate when the pressure in the installation has fallen to a value of not less than the highest design pressure requirement for the system. Where pressure sensors serve more than one installation, they shall be duplicated (wired in parallel) for each pump.

Where more than one pump is provided, the pumps shall be arranged to start sequentially at a pressure not less than that stated above.

- g) A fall in water pressure in the sprinkler system, which is intended to initiate the automatic starting of the pump, shall at the same time provide a visible and audible alarm at some suitable location, eg. in the Fire Command Centre or at the installation control valves. The starting of the pump(s) shall not cause the cancellation of the alarm.

NOTE – It is also recommended that where the pump is situated remote from the protected premises, visible and audible indication of the pump operation be provided at some similar suitable location. This may share a common indicator with the demand alarm.

- h) Power for the above warning system shall be independent of the power supply to an electric pump, or of the battery which is used for starting a compression-ignition engine driven pump.
- i) Power sufficient to drive the pump at the required pressure shall be available at all times.
- j) Facilities shall be provided to reduce the applied water pressure to each starting device to simulate the condition of automatic starting at the required pressure.

NOTE 1 – This can take the form of a drain valve on the hydraulic connection to the pump starting pressure switch with the provision of suitable permanent drainage facilities. To enable the cut-in pressure to be judged accurately, the drain valve may be fitted with an orifice plate to reduce the rate of pressure drop.

NOTE 2 – To facilitate testing and servicing, an isolating valve with a bypass should be fitted on the hydraulic connection. The bypass is to incorporate a 3 mm orifice and a non-return valve allowing flow towards the main. A pressure gauge to indicate the pressure at which the pump starts is to be located between the isolating and drain valves such that it can be read during the pump starting test (see Figure 11).

- k) Pumps shall be driven either by an electric motor or an approved compression-ignition type engine.

5.11.2 Electric motor driven pumps

5.11.2.1 Electric drivers

- a) General

All electrical drivers shall be of the cage rotor induction type complying with the relevant portions of AS 1359 and shall have a degree of protection not inferior to IP54 in accordance with AS 1939.

- b) Types of wiring

All wiring associated with pump motors, from the point of entry onwards and all wiring up to and including each pump motor shall be either:

- 1) mineral insulated metal sheathed (MIMS) cable;
- 2) sheathed or unsheathed cable in metallic wiring enclosures; or
- 3) any wiring method that meets the requirements of AS 3000 and AS 3013.

NOTE – It is strongly recommended that all external wiring be installed underground.

c) Basis of rating

Electric motors shall be of S1 duty rating for maximum continuous rating (MCR) (see AS 1359.30) and of voltage rating to suit the supply voltage. Motors shall have power ratings at least equal to the following % ages of the pump rated power:

Motor rating KW	Pump rated power %
≤ 18.5	125
$\geq 22 \leq 55$	115
≥ 75	115

Motors used at altitudes above 1000m shall have reduced temperature rises as specified in AS 1359.10.

When measured at rated voltage, the locked-rotor apparent power of the motor (S1) in kilovoltamperes, expressed as a per unit (p.u.) value of the rated output (P_n) in kilowatts shall not exceed the appropriate value as follows:

Motor output KW	Maximum locked-rotor apparent power (S1) p.u rated output*
$> 0.4 \leq 6.3$	9.8
$> 6.3 \leq 25$	9.0
$> 25 \leq 100$	8.3
$> 100 \leq 6.30$	7.5

d) Motor construction

Current-carrying parts of an electric motor, including the terminal box, shall be at least 300mm above the floor.

Where unusual moisture or abrasive dust conditions are likely to be encountered, the motor shall be of a special type or to be especially protected to withstand such conditions.

5.11.2.2 Electric controllers

a) General

An individual fire pump motor controller shall be provided for each fire pump and shall have a degree of protection not inferior to IP54 in accordance with AS 1939.

b) Location

Controllers shall be within sight of the drivers they control and should be positioned as close as practicable thereto.

c) Controller cabinets

Controller cabinets may be freestanding, wall-mounted, or mounted integrally with the pumpset. Cabinets designed for floor or integral mounting shall have a minimum of 300 mm clearance between floor level and live parts. Cabinets designed for wall mounting shall state on the internal wiring diagram that a minimum of 300 mm clearance shall be maintained between the floor level and the current carrying parts.

Cabinets shall incorporate one or more hinged lockable access doors and be dimensioned to provide ready access to internal components. A high-impact resistant viewing panel not exceeding 40% of the door area is permissible.

d) Isolating switch

Where pump motors are automatically controlled, a manually-operated isolating switch connected on the supply side of the fire pump controller, and operating in all active conductors, shall be provided. The isolating switch shall comply with AS 1775.

Where incorporated within the cabinet, the isolating switch shall be capable of being operated externally, and being locked in the 'on' position (power supply on).

The isolating switch shall be provided with a protective cover, or boot, and a warning label on the 'live' side of the switch which shall be marked "Live Terminals". The warning label may utilise the international symbol for live electrical equipment.

e) Motor starter

The motor starter shall comply with appropriate requirements of AS 1202.1 to AS 1202.5 but the thermal overload relay shall not be connected to trip the starter.

NOTE – The thermal overload relay may be omitted from the motor starter or it may be used to provide a visual or aural indication that the motor has exceeded its thermal rating.

The transition through the starting steps of reduced voltage starters to AS 1202.2 to AS 1202.5 inclusive shall be automatic (i.e. independent of an operator). The motor shall attain full speed within 15 s of receipt of start signal.

The starters shall be rated for intermittent duty class 0.1.

f) Equipment segregation

Low and extra-low voltage components and associated wiring and terminal strips shall be located in separate compartments within the sprinkler pump controller in accordance with AS 3000.

NOTE 1 – Cables in the same enclosure. Cables of low and extra low voltage circuits are not to be contained within the same enclosure unless:

- a) low voltage cables are of a type providing the equivalent of double insulation;
- b) all cables are insulated for the highest voltage present; or
- c) the low voltage cables are run in a separate channel of a common trough, provided the channel is separated by fixed and continuous barriers.

NOTE 2 – Separation of cables at terminations. Where cables of different systems are terminated within the one enclosure, the wiring and connection of the low voltage cables will be effectively separated from the other cables by means of rigidly fixed screens or barriers, or by other effective means.

Mixed voltage (e.g. 240 V a.c/ 24 V d.c) components shall be located in the compartment provided for the higher voltage and labeled accordingly.

NOTE 1 – Extra-low voltage. Not exceeding 32 V a.c or 115 V d.c.

NOTE 2 – Low voltage. Exceeding extra-low voltage, but not exceeding 1000 V a.c or 1500 V d.c.

g) Control devices

In addition to the isolating switch, the sprinkler pump controller shall have externally operable manual stop and start switches.

The operation of the manual stop switch shall automatically return the sprinkler pump controller to the automatic start position.

The operation of the manual start switch shall override any automatic start facilities.

h) Indicator lights

Indicator lights shall be of the filament, neon, or light emitting diode (LED) types. If filament lights are used, they shall be either twin metal filament type or two individual lights, and the voltage applied shall not exceed 80% of the rated voltage of the lights. All lights shall be accessible for replacement. Indicator lights shall be colour-coded as follows:

1)	Power supply to pump present (all phases)	—	green
2)	Phase failure	—	red
3)	Pump running (alarm condition)	—	red
4)	Battery charger supply failure	—	red

NOTE — It is considered that one light for each function is appropriate except where filament lights are required.

i) Aural alarm

An aural alarm integral with the sprinkler pump controller shall be provided and protected against an overcurrent of 150%. If a remote aural alarm is provided, the integral alarm may be omitted.

A suitable location for the aural alarm may be at a manned plant guardhouse or fire command center.

The aural alarm shall operate simultaneously with the lights indicating power supply failure, phase failure, and pump running (alarm condition) indications.

The sound level output shall exceed normal background levels by not less than 10 dBA, but in any case shall be not less than 65 dBA and not more than 105 dBA.

j) Alarm power supply

The power supply for the indicator lights and alarms shall be taken from a battery having a capacity sufficient to energise the alarm and indicator system for a minimum period of 72 h.

NOTE — This does not preclude the use of an alternative reliable source of supply in lieu of batteries.

k) Test facility

A test facility shall be provided for the testing of indicator lights and audible alarms.

l) Ammeter

An ammeter shall be provided on the face of the sprinkler pump controller cabinet to indicate selectively the phase currents of the motor.

m) Conductor terminations

Conductor terminations shall be achieved in the following ways:

- 1) Control conductors shall utilise numbered tunnel type terminal blocks incorporating studs or screws for both internal and outgoing conductors.

Conductors shall be correspondingly numbered and provided with compatible terminals, the shanks of which shall be insulated.

Conductors shall be of sufficient length to allow a fresh termination to be made should the original break off.

Conductors which do not have to be terminated shall be left long enough to reach the furthestmost point on the terminal block.

Conductors shall be grouped together and laced neatly wherever possible.

- 2) Power conductors shall be terminated with swaged terminations that are bolted.

n) Battery

The battery shall be installed in a separate ventilated enclosure or on brackets with the battery base at least 150mm above the floor, and shall be fitted with a non-conductive cover.

The battery shall not be installed within the sprinkler pump controller.

Batteries shall be of the lead-acid types complying with AS 4029.2 or AS 4029.3 or be of the nickel-cadmium type complying with AS 3731. In addition they shall comply with the following:

- 1) The construction of the battery shall enable it to accept a float/trickle charge without breakdown or significant reduction in its service life.
- 2) Service life shall be rated at not less than 5 years.

o) Battery charges

A constant potential battery charger, matched to the type of battery used, shall be provided to service the alarm and indicator light battery. The charger shall be capable of fully recharging the battery from 50% capacity within a period of 24 h.

The battery charger, together with associated ammeter and voltmeter, shall be incorporated into the sprinkler pump controller cabinet.

p) Wiring diagrams

A complete set of wiring diagrams, including that for the driver, shall be provided and permanently attached to the inside of the enclosure and protected by a transparent durable cover.

The diagrams shall be numbered to coincide with sprinkler pump controller terminals.

q) Marking

Each driver control device and each switch and circuit-breaker shall be marked to indicate plainly the name of the manufacturer, and manufacturer's model designation.

All sprinkler pump controller cabinets shall be marked 'Electric Sprinkler Pump Controller' and show plainly the name of the manufacturer, model number and applicable rating.

All indicating lights, switches, and meters shall be provided with designating, permanently secured/fixed labels.

r) Access for inspection and testing

Where sprinkler pump controllers require rear access for inspection or servicing, a clear space of not less than 600 mm shall be provided at the rear of the cabinet.

A clear space of not less than 600 mm shall be provided at the sides of the cabinet to permit inspection and servicing.

s) Pre-delivery testing

Controller shall be completely assembled, wired, bench-tested and certified by the manufacturer before dispatch.

5.11.2.3 Field wiring

All field wiring associated with the satisfactory operation of a fire sprinkler pumpset shall comply with the requirements of CP 5.

5.11.3 Compression-ignition drivers and controllers

5.11.3.1 General requirements

a) Driver type

The driver shall be of the compression-ignition mechanical injection type, be liquid-cooled or air-cooled, and comply with the performance requirements of 5.11.3.2(b) as below. The driver shall be capable of being started without the use of wicks, cartridges, heater plugs or other starting devices, and shall have a degree of protection not inferior to IP23.

Compliance with the starting requirements may necessitate fitting jacket heating equipment to either the driver cooling system or the lubricating system.

b) Power transmission

Drivers shall be directly coupled to the pump with suitable flexible couplings to transmit the full power of the engine and maintain axial alignment of the driveline; however, a right-angle gear drive and universal joints may be incorporated in the driveline for vertical turbine pumps.

Chain drives, belt drives, clutch drives, or fluid drives shall not be used.

5.11.3.2 Driver performance

a) Fuel

The driver shall be designed to operate on fuels complying with the requirements of AS 3570 and ASTM D975 for class no. 2D or BS 2869.2 for class A1 fuels with a minimum cetane number of 45.

b) Power rating and speed

The site rating shall be determined in accordance with AS 2789.1 to AS 2789.6 at the governed speed of 65% and shall be not less than 115% of the power to operate the actual pump unit selected to achieve the pump performance required by this code.

NOTE – The adjustment to determine the site rating is to be applied to the engine manufacturer's continuous rated power application when the driver is operating under standard condition.

c) Service life

Compression-ignition sprinkler pump drivers are expected to perform reliably under normal application conditions for a minimum of 2000 h between overhauls or 5 years, whichever comes first.

d) Starting capability

The driver shall be capable of starting from cold and accelerating to full speed within 15 s of the cranking cycle initiated under all extremes of site conditions.

5.11.3.3 Driver systems

a) Lubrication system

Drivers shall be equipped with a suitable pressure-type lubrication system. The system shall comprise a direct engine driven pump, a filter and distribution system, and shall have adequate capacity to maintain lubricant temperatures within the range recommended by the lubricant manufacturer.

The lubrication filter medium shall be readily replaceable or the filter shall be of the type allowing ready cleaning.

Accessible means shall be provided for checking, draining, and replenishing the lubricant supply.

The lubrication system shall not leak.

b) Cooling system

The manufacturer shall state the desirable operating temperature range for the driver. The cooling system shall automatically maintain the driver within the desirable operating temperature range. The temperature regulating device shall be designed to provide maximum cooling in the event of its failure.

Vee-belt drives forming part of the cooling system shall incorporate multiple belts so that if half the belts break, the remaining belts shall be capable of performing the drive functions.

NOTE – This does not preclude the use of approved single belt drives, including automatically tensioned multiple-rib belt drives, provided that reliability is judged equivalent to multiple Vee-belt drives with 100% redundancy.

c) Liquid cooling system

Liquid cooling system shall have a closed primary loop. The heat from the primary loop may be dissipated either directly to the atmosphere or to a secondary open, raw water cooling circuit. Liquid cooling systems shall be provided with an opening in the primary loop for replenishing the coolant or checking the liquid level. An expansion reservoir shall also be provided to minimise loss of coolant due to thermal expansion and contraction.

Where the primary coolant heat is dissipated directly to the atmosphere, an engine- driven fan shall be provided for positive movement of air through the heat exchanger. The heat exchanger shall be designed to maintain normal engine operating temperatures, with an inlet air temperature of 50°C.

Where raw water secondary coolant is used, the flow and pressure of the raw water shall be such that the maximum operating temperature of the engine will not be exceeded at the rated speed. The raw water outlet shall be at least one pipe size larger than the inlet. The cooling water line shall be arranged so that the discharge is visible and includes a bypass.

NOTE – Flow and pressure requirements for secondary coolants are usually specified by the engine manufacturer.

d) Air cooling systems

Air cooling systems shall provide an engine-driven fan and a connection to discharge coolant exhaust air outside the pump room. Sufficient venting area to comply with the engine manufacturer's requirements shall be provided. The system shall be designed to maintain normal engine operating temperature, with an inlet air temperature of 50°C.

e) Supplementary cooling systems

Supplementary cooling devices such as lubricant and inlet air coolers are permissible if they share raw water or coolant air supplies with the primary engine cooling systems specified above.

f) Fuel system

1) General

The fuel system shall comply with the following:

- i) The fuel system shall include a fuel filter with readily replaceable filtering medium.
- ii) A sludge and sediment trap shall be provided in the fuel system ahead of the fuel filter.
- iii) Fuel system connections to and from the engine shall incorporate flexible connections of the metallic type.
- iv) The size of fuel supply lines shall be in accordance with the engine manufacturer's recommendations.
- v) Fuel lines on the engine shall be of metal.
- vi) The fuel system shall be leak-free during all phases of engine operation.
- vii) All valves in the fuel line between the fuel tank and the engine shall be capable of being locked in the open position.

2) Fuel tank

The fuel tank shall comply with AS 1692, and be fitted with an indicator showing the level of the fuel in the tank. If there is more than one compression engine driven pumpset, there shall be a separate fuel tank and fuel feed pipe for each engine.

The capacity of the fuel tank shall be sufficient to allow the engine to run on full load for a minimum of 4 hours.

NOTE – Four hours is regarded as the minimum time. Some risks may require tanks with a larger capacity.

Precautions should be taken to minimise adverse effects on the tank due to vibration.

3) Fuel tank location

The fuel tank shall be located so as to provide gravity feed to the engine fuel pump and to prevent spillage of fuel over or around the driver. Whenever practicable, the fuel tank shall be located adjacent to the driver. The fuel tank shall be mounted independent of the driver baseplates or be fitted with appropriate vibration-resistant mountings.

g) Air induction system

The air intake or induction system shall have degree of protection not inferior to IP23 and be equipped with a suitable filter to prevent dust and debris from entering the driver. The filter shall be designed for easy replacement or cleaning of the filtering medium.

The air intake to the driver may be equipped with a connection to duct intake air from outside the pump room in accordance with the manufacturer's recommendations.

h) Exhaust system

The exhaust system shall be gastight throughout the operating range of exhaust temperatures and pressures. It shall be designed with an outlet connection to readily discharge exhaust gases outside the pump room, and shall be fitted with a flexible connection to prevent transmission of vibration from the driver to the exhaust system. The system shall be suitably guarded or cooled to prevent fire hazards and injury to operators.

The exhaust system shall be fitted with a suitable silencer, and the total backpressure shall not exceed the engine maker's recommendation. If the exhaust system rises above the driver, means shall be provided at the low point of the exhaust pipe to preclude the ingress of condensate into the engine. This preventative means shall be downstream of the turbocharger (if fitted).

The exhaust silencer shall be such that the sound pressure level is suitable for the environment.

i) Starting and stopping systems

1) General

Starting system shall be either battery-powered or air-powered. Either system shall incorporate two power sources, one for automatic starting and one for manual starting. A crank handle shall also be permitted if engine size permits.

2) Battery-powered starting systems

The starting system shall operate from either of two batteries with automatic and manual start operation provided from the start battery, and a manual start operation from the control battery.

Each automatic and manual starting system shall have the capacity to provide a minimum 3 min (15 s intermittent cranking with 15 s rest) cycle at full rate cranking speed at 4.4°C ambient temperature.

The electric starter motor shall incorporate an axial displacement pinion which engages the engine flywheel ring by means of solenoid action, and which has no retaining catches or inertial features. The pinion shall rotate at reduced speed while engaging with the flywheel ring. When the engine fires, the starter motor pinion shall be withdrawn from the flywheel ring automatically. Withdrawal of the pinion shall be initiated by an electromechanical speed sensing device and not by the use of pressure switches, e.g. on engine lubricating system or water pump outlet. Where centrifugal speed switches or voltage generators are used for speed sensing, they shall have a direct coupling to, or be gear-driven by the engine. Flexible drives shall not be used.

Repeat engagement facilities shall be provided to allow for the pinion's failure to engage with the engine flywheel ring. If the pinion fails to engage, the mechanism shall continue to attempt engagement while battery power is available.

A switch shall be provided in the starter motor solenoid control circuit to prevent the starter from being energised during maintenance. When this switch is operated, an automatic warning shall be given aurally and visually at a suitable location, e.g. in the gatehouse or at the installation control valves.

The primary and secondary manual start switches shall be mounted adjacent to each other on the engine. The switches shall be sealed so that, when operated, the broken seal is obvious. Relays may be used to reduce the current at the switches.

3) Batteries

The battery shall be installed in a separate ventilated enclosure or on brackets with the battery base at least 150 mm above the floor and fitted with a non-conductive cover.

Batteries shall not be installed in the sprinkler pump control panel.

Batteries shall not be installed on the diesel pump set baseplate unless vibration-resistant battery mountings are installed.

Batteries shall be of the lead-acid types complying with AS 4029.2 or AS 4029.3 or be the nickel-cadmium type complying with AS 3731. In addition they shall comply with the following:

- i) Battery size shall be such that each starting system is capable of complying with the cranking requirements of 5.11.3.3(i)(2) above;
- ii) The construction of the battery shall enable it to accept a float/ trickle charge without breakdown or significant reduction in its service life;
- iii) Service life shall be rated at not less than 5 years.

NOTE – Starter batteries should be arranged as close as possible to the starter motor to minimise voltage drop. Battery leads should be adequately supported.

4) Engine generator/ alternator

The engine shall have a generator or alternator to recharge the starting batteries.

5) Air-powered starting systems

The systems shall operate from appropriately sized air receivers. Controls shall be normally automatic in operation, but a manual control (electrical or mechanical) shall also be provided.

The air-driven starter motor shall incorporate an axial displacement pinion which engages the engine flywheel ring and which has no retaining catches or inertial features. The pinion shall rotate at reduced speed while engaging with the flywheel ring. When the engine fires, the starter motor pinion shall be withdrawn from the flywheel ring automatically. Withdrawal shall be initiated by an electromechanical speed sensing device and not by the use of pressure switches, e.g. on engine lubricating system or water pump outlet. Where centrifugal speed switches or voltage generators are used for speed sensing, they shall have a direct coupling to, or be gear-driven by, the engine. Flexible drives shall not be used.

Repeat engagement facilities shall be provided to allow for the pinion's failure to engage with the engine flywheel ring. If the pinion fails to engage, the mechanism shall continue to attempt engagement while air power is available.

In addition to the air receiver for automatic starting, a second air receiver of equivalent size and type shall be provided for manual starting. Each of these air receivers shall be capable of independently powering the starter motor as required above.

An isolating valve shall be provided in the starter motor air supply line to prevent the starter from being energised during maintenance. When this valve is operated, an automatic warning shall be given aurally and visually at a suitable location, e.g. in the gatehouse or at the installation control valves.

The manual control for the starter motor shall be mounted on the compression-ignition engine, and be connected to the air receiver supplying air to the starter motor. The manual control shall be sealed so that the breaking of the seal is obvious when servicing is being carried out.

6) Air receivers

Air receivers shall comply with AS 1210.

Receiver size shall be such that each starting system motors shall be sized and arranged to minimise pressure drop. Piping should be as short as possible. Piping and valves shall be sized in accordance with manufacturer's recommendations.

7) Air supply

Each air receiver shall be maintained at the required working pressure by a dedicated automatic air compressor or other equally reliable air supply.

Air receivers shall be continuously monitored so that an aural alarm is sounded on low air pressure.

8) Engine shut-down systems

A shut-down mechanism shall be mounted on the engine. It shall be manually operated and return automatically to the starting position after use.

Automatic shut-down mechanisms shall not be permitted. Additional shut-down by means of a hold-on push button and normally open solenoid controlled shut-off device is permitted.

The additional shut-down facility shall also be arranged to return automatically to the starting position after the push button is released.

j) Instrumentation

The following minimum panel-mounted instrumentation shall be provided:

- 1) A tachometer (preferably of the electronic type) marked at the normal engine running speed (flexible drives are not acceptable).
- 2) An hour meter to indicate the total time of operation.
- 3) An oil pressure gauge to indicate engine lubricant pressure and marked to designate normal operating condition.
- 4) Engine temperature gauge, marked at the normal engine operating temperature. Liquid-cooled engines shall be provided with a temperature gauge to monitor the primary coolant temperature. Air-cooled engines shall be equipped with a temperature gauge to monitor either the lubricant temperature or the external surface temperature of the engine nearest the point of combustion.
- 5) An ammeter to indicate the charging rate of the engine-mounted generator/alternator.

The instrument panel shall be securely mounted in a vibrating-free location that does not subject operation personnel to unreasonable hazard from hot surfaces or moving parts of the engine, pump, or power transmission equipment.

All control devices shall be rigidly attached to the engine. Any devices which must be wired to a specified sprinkler pump controller shall be wired to a junction box. All wiring shall be harnessed or suitably enclosed and protected from mechanical, thermal, or engine fluids damage. The junction box shall be rigidly attached to the engine or baseplate. Terminals and junction box shall be arranged to facilitate external wiring to the engine fire pump controller.

k) Governor

The engine shall be provided with a governor to control the engine speed within 5% of its rated speed under any condition of load up to the full load rating.

l) Guards

Guards shall be provided to cover fully all flexible couplings, belt drives, and other accessible moving parts.

m) Marking

Each of the following items shall be legibly and indelibly marked as specified:

- 1) For battery-powered starting system the manual start switches shall be marked with the words 'MANUAL START: START BATTERY' and 'MANUAL START: CONTROL BATTERY', as appropriate;
- 2) For an air powered starting system the manual start valves shall be marked with the words 'MANUAL START: MANUAL AIR RECEIVER' and 'MANUAL START: AUTOMATIC AIR RECEIVER', as appropriate.

5.11.3.4 Compression-ignition driver controllers

a) General

An individual sprinkler pump controller shall be provided for each sprinkler pump, and shall have a degree of protection not inferior to IP54 in accordance with AS 1939.

Controllers shall be compatible with compression-ignition engine-driven sprinkler pumps.

Controllers shall be assembled, wired and tested by the manufacturer prior to installation.

b) Location

Controllers shall be positioned as close as practicable and within sight of the drivers they control.

c) Controller cabinets

Controller cabinets may be freestanding, wall-mounted, or mounted integrally with the pumpsets. Controllers designed for floor or integral mounting shall have a minimum of 300mm clearance between floor level and current-carrying parts. Controllers designed for wall mounting shall state on the internal diagram that a minimum of 300 mm clearance shall be maintained between the floor level and the live parts.

Cabinets shall incorporate one or more hinged lockable access doors and be sized to provide ready access to internal components. A high impact-resistant viewing panel not exceeding 40% of the door area is permissible.

d) Isolating switch

Where incorporated within the fire pump controller, the isolating switch shall be capable of being operated externally and be capable of being locked in the 'on' position (power supply on).

The isolating switch shall be provided with a protective cover, boot, or warning label on the 'live' side of the switch shall be labeled "Live Terminal". The warning label may utilise the international graphic symbol for live electrical equipment.

e) Equipment segregation

Low and extra-low voltage components and associated wiring and terminals strips shall be located in separate compartments within the fire pump controller in accordance with AS 3000.

f) Control functions

The fire pump controller shall incorporate all circuits and components associated with the following:

- 1) Automatic starting (cyclic cranking);
- 2) Manual starting;
- 3) Speed sensing;
- 4) Alarm and status indication;
- 5) Automatic resetting to stand-by start position on shut-down;

- 6) Control-circuit isolation;
- 7) Indicator lights and aural alarm test facility.

g) Indicator lights

Indicator lights shall be of the filament, neon, or LED types. Where filament lights are used, they shall be either twin metal filament type or two individual lights, and the voltage applied shall not exceed 80% of the rated voltage of the lights. All lights shall be accessible for replacement.

Indicator lights shall be colour-coded as follows:

- | | | | |
|----|---|---|-------|
| 1) | Power supply to sprinkler pump controller present | – | green |
| 2) | Failure of engine to start automatically | – | red |
| 3) | Automatic start circuit disconnected | – | red |
| 4) | Pump running | – | red |
| 5) | Battery charger supply failure | – | red |
| 6) | Aural alarm silenced | – | red |

h) Aural alarm

An aural alarm integral with the sprinkler pump controller shall be provided and protected against an overcurrent of 150%. Should a remote aural alarm be provided, then the integral alarm may be omitted.

The aural alarm shall operate simultaneously with the lights indicating pump running, battery charger supply failure, failure of engine to start automatically, and diesel start circuit disconnected. This alarm may also indicate abnormal engine running conditions.

The sound level output shall exceed normal background levels, but in any case shall be not less than that of a 100 mm diameter underdome bell.

An additional alarm may be provided at a manned plant, gatehouse, or control center.

i) Conductor terminations

Numbered tunnel type terminal blocks incorporating studs or screws shall be provided for internal and outgoing conductors.

Conductors shall be correspondingly numbered and provided with compatible terminals, the shanks of which shall be insulated.

Conductors shall be of sufficient length to allow a fresh termination to be made should the original break off.

Conductors which are not required to be terminated shall be left long enough to reach the furthestmost point on the terminal block.

Conductors shall be grouped together and laced neatly wherever possible.

j) Mains wiring to controller

All wiring from the supply mains to the sprinkler pump controller shall be:

- 1) MIMS cables;
- 2) sheathed or unsheathed cable in metallic wiring enclosure;
- 3) busways with metallic enclosures; or
- 4) other wiring providing a degree of security against fire and mechanical damage in accordance with AS 3000.

k) Controller to driver interconnecting wiring

Where the sprinkler pump controller forms an integral part of the sprinkler pump assembly, the wiring shall be connected from the sprinkler pump controller terminal strip either directly to the driver ancillaries or to a separate engine-mounted terminal strip enclosed in a junction box.

If the sprinkler pump controller is independent of the fire pump assembly, the interconnecting wiring shall be by means of a flexible cable with a self-indexing, lockable pin plug and socket connections.

NOTE – The pin plug and socket cable is intended to facilitate shop testing installation. For the purpose of this Standard, a maximum cable length of 4 m is recommended.

l) Battery chargers

Two battery chargers of the constant potential type compatible with the battery being charged, each with separate transformers, ammeters, and voltmeters, shall be incorporated into the sprinkler pump controller. The chargers shall have automatic in-built current-limiting facilities. Chargers shall be capable of fully recharging each battery from 50% capacity within a period of 24h. One charger shall service the engine automatic starting battery; the other shall service the engine manual starting battery.

m) Generator/Alternator isolation

Automatic means shall be provided to isolate the generator/alternator when the mains-powered battery charger is in operation, i.e. when the engine is stopped.

n) Locked switches

All switches required to keep the sprinkler pump controller in the 'automatic' position shall be locked in the 'on' position.

o) Instructions

Complete instructions covering the operation of the sprinkler pump controller shall be provided and conspicuously mounted on the sprinkler pump controller.

p) Access for inspection and testing

If sprinkler pump controllers require rear access for inspection or servicing, a clear space of not less than 600 mm shall be provided at the rear of the sprinkler pump controller.

A clear space of no less than 600 mm shall be provided at the sides of the fire pump controller to permit inspection and servicing.

q) Pre-delivery testing

Controllers shall be completely assembled, wired, batch-tested and certified by the manufacturing before dispatch.

r) Wiring diagram

A wiring diagram shall be provided and permanently attached to the inside of the enclosure. The wiring diagram shall be suitably protected.

s) Marking

Each operating component of the sprinkler pump controller shall be marked to plainly indicate an identifying number referenced to the wiring diagram. The markings shall be located so as to be visible after installation.

All starting equipment shall be clearly marked 'Sprinkler Pump Controller' and shall also show manufacturers name, the model and the serial numbers, and the electrical rating.

5.11.3.5 Electrical connections on engine

Where push-on or quick-connect fittings are used for wire termination, they shall be fixed in an approved manner. Their current rating shall not be exceeded. If insulation is necessary, this shall not be achieved by the use of insulating tape. Where vibration or mechanical damage is likely to be encountered, accidental disconnection of this type of fitting shall be prevented by suitable means.

NOTE – One suitable method is to fasten the blades by a screw, nut and spring washer.

The use of any plug and socket arrangement for the connection of wiring between the sprinkler pump controller and engine components is not precluded by the above, but satisfactory means of securing the plug in position shall be provided.

All wiring on the engine and between the engine and batteries shall be run in automotive flexible cable.

5.11.3.6 Spare parts

A list of spare parts for the maintenance of both the engine and the pump shall be drawn up and the spare parts shall be kept on site. The items listed and the numbers held shall be influenced by the supply time from the nearest reliable source.

5.12 Proving of water supplies

5.12.1 General (see Figure 12 and Figure 13)

Facilities shall be provided at the installation valve on each system to enable tests to be carried out to verify that the water supply satisfies the pressure/ flow requirements appropriate to the hazard class (see 10.2, 11.2 or 12.2). These facilities shall consist of one of the following:

- a) An approved proprietary device installed in accordance with such approval;
- b) A pressure differential device manufactured and installed in accordance with BS 1042:Part 1.

Where there are a number of installation control valves associated with installations of the same hazard class, this testing facility is only necessary on one installation control valve, provided that it is fitted to the valve which is hydraulically the most unfavorably situated.

Where more than one hazard class is involved, whether on the same or separate installation control valves, testing facilities shall be provided to enable the full range of flows to be measured.

A permanent name plate giving the designated occupancy hazard classification and the pressure/flow requirements of the particular system shall be posted at the installation valve.

NOTE – This requirement may be waived by the relevant authority where it is obvious, from testing of the higher flow rate, that the lower pressure/flow requirements are satisfied.

5.12.2 Automatic pumps

In addition to the requirements of 5.11.1(d), the facilities required in 5.12.1 shall be provided for installations supplied by automatic pumps.

When the effective pressure/ flow characteristics of these supplies are being assessed, account shall be taken of pressure losses in the supply pipe and valves between the supply and the installation gauge during discharge at the maximum rate of flow for the hazard class. These losses shall be calculated using the appropriate formula in clause 13, Table 6 or 7, as appropriate.

NOTE 1 – It is recognised that in some instances a single testing device can satisfy the requirements of 5.11.1(d) and 5.12.1. In such a case, the relevant authority may accept the single testing device.

NOTE 2 – Care should be taken, when water supplies are marginal, to ensure that pressure losses in the drain pipe are not so high as to restrict the flow across the testing facility below the required test pressure and flow. This applies particularly where the required flow rate is high, or where the highest sprinklers are below the installation gauge or only slightly above it.

Table 6 – Pressure loss for medium ^a tubes to SS 17

Nominal internal pipe size Mm	Loss of pressure per metre length of pipe ^a kPa
25	56.8
32	14.8
40	7.1
50	2.27
65	0.64
80	0.29
100	0.08
150	0.012
200	0.0029

NOTE – For heavy tubes, the losses are calculated for a flow of 400 L/min from the data given in clause 13.
^a Calculations for the ringed portions of distribution pipes are to be based on these pressure losses on the total length of each pipe size multiplied by a factor of 0.14.

Table 7 – Value of K for steel tubes to SS 17

Nominal internal pipe size Mm	Value of K	
	Medium tube	Heavy tube
25	8.80×10^{-4}	1.19×10^{-3}
32	2.29×10^{-4}	2.86×10^{-4}
40	1.09×10^{-4}	1.32×10^{-4}
50	3.46×10^{-5}	4.06×10^{-5}
65	9.79×10^{-6}	1.11×10^{-5}
80	4.47×10^{-6}	4.95×10^{-6}
100	1.23×10^{-6}	1.35×10^{-6}
150	1.83×10^{-7}	1.89×10^{-7}

NOTE – Pipes larger than above or of alternative material must comply with 8.1. Certified manufacturers' certificates must be supplied with hydraulically calculated pipework when required by the relevant authority.

6 Spacing and location of sprinklers

6.1 Standard spacing

The maximum area coverage per sprinkler and maximum distance between sprinklers on range pipes and between adjacent rows of sprinklers shall be as specified for the class of hazard (see 10.3, 11.3 and 12.3 and Figure 14).

6.2 Staggered spacing

Where sprinklers are required to be staggered (see 6.4.4), the arrangements shall be uniform. The distance from the end sprinkler to the wall or partition in each alternate row shall be one-fourth of the design sprinkler spacing down the row; the spacing of the next sprinkler in the same row shall be three-fourths of the design spacing (see Figure 15).

6.3 Minimum distance between sprinklers

Sprinklers should not be spaced closer than 2 m except where intervening constructional features provide a satisfactory baffle or where special baffles are installed in order to prevent the first sprinkler which operates from wetting adjacent sprinklers.

Baffles shall be 200 mm wide x 150 mm high and preferably of sheet metal. They shall be located approximately midway between sprinklers and arranged to baffle the actuating elements. The top of the baffles should extend above the sprinkler deflectors by 50 mm to 75 mm.

6.4 Location of sprinklers (other than sidewall sprinklers)

6.4.1 General

In addition to limitations specified for the maximum area coverage per sprinkler and the maximum distance between sprinklers (see 6.1), sprinklers shall be so located that there will be minimal interference to the discharged pattern by structural members such as beams, columns, girders and trusses (see 6.4.4, 6.4.5, 6.4.6 and 6.4.7) or any other obstructing feature. Sprinklers shall also be located at the appropriate distance below ceiling and beams as required by 6.4.3.

6.4.2 Walls and partitions

Except as provided for in 6.2, the distance of sprinklers from walls or partitions shall be as specified for the appropriate hazard class (see 10.3.3, 11.3.3 or 12.3.3).

For open-joisted ceilings or where the roof has the rafters exposed, the distances from walls and partitions referred to in 10.3.3, 11.3.3 or 12.3.3, as appropriate shall not exceed 1.5 m.

Sprinklers shall be placed not more than 1.5 m from external walls where these are constructed of:

- a) combustible material;
- b) fibrous cement or metal, with combustible lining in either case; or
- c) metal (whether on wood or metal frame and with or without combustible lining) protected with a coating of bitumen, tar or pitch, or with material impregnated or treated with bitumen, tar or pitch.

Open-faced buildings shall have sprinklers not more than 1.5 m from the open face.

6.4.3 Ceilings, roofs and underside of stairs

The following requirements apply to sprinklers located below ceilings, roofs and stairs:

NOTE – Where practical, as in the case of false ceilings, sprinklers should be located such that the deflectors are within 75mm and 150mm of the ceiling.

- a) Sprinkler deflectors shall be parallel to any slope of the ceiling, roof or underside of stairs.
- b) Spacing measurements shall be taken horizontally.
- c) When fitted under a sloping surface which is greater than 1 in 3, a line of sprinklers shall be fitted at the apex unless there is a row of sprinklers at a radial distance not greater than 750 mm from the apex.
- d) Sprinklers shall be located not more than 300 mm below combustible or frangible ceilings or roofs.
- e) Sprinklers shall be located not more than 450 mm below ceilings or roofs containing no combustible material. Where combustible sarking, insulation or linings, etc. are installed below ceilings or roofs, such ceilings or roofs shall be deemed to be combustible.
- f) Deflectors shall be not more than 150 mm below joists of open-joist ceilings.
- g) For open joists and exposed common rafter construction, measurements shall be taken from the underside of joists or rafters.
- h) Unless otherwise approved, measurements in (d) and (e) above for arched ceilings or ceilings of irregular shape shall be taken from the highest points in the ceiling.
- i) For waffle type concrete floor slabs not exceeding 1.5 m², deflectors shall be not more than 150 mm below the soffit of the waffle beam.
- j) Sprinklers shall not be recessed in ceilings unless specifically manufactured for such mounting.

6.4.4 Beams and joists

Light fittings and ducts in close proximity to the ceiling shall be treated as beams or joists.

Where deflectors of sprinklers are above the level of the bottom of the beams or joists (because of the limitation imposed by 6.4.3), the sprinklers shall be at such distances that undue interference with the sprinkler discharge pattern is avoided.

NOTE – Table 8 and Figure 16(a) indicate the minimum horizontal distances for sprinklers:

- a) from the side of a beam or joist in relation to the height of the deflector; and
- b) above the bottom of the beam or joist.

Figures 16 (b) and 16 (c) give examples of these distances.

Where the depth of the beam (or joist), *c*, (see Figure 16(a)) exceeds 300 mm (combustible ceilings) or 450 mm (non-combustible ceilings) and it is impracticable to position sprinklers at the required distance from the side of the beam, the beam shall be treated as a wall insofar as the sprinklers in the adjoining bay are concerned.

Where the depth of beams (or joists) is such that the dimensions specified in Table 8 cannot be complied with and the beams (or joists) are spaced closer than 1.8 m measured from centre-to-centre of beam, the sprinklers shall be stagger-spaced (see 6.2).

NOTE – Where beams of the above depth are spaced closer than 1.2 m, they should be underdrawn with substantial noncombustible material.

Table 8 – Sprinkler distances from beams and joists (for sidewall sprinklers, see Table 9)

Minimum horizontal distance from sprinkler to side of beam or joists, a mm	Maximum height of sprinkler deflector above bottom of beam or joist, b mm	
	Conventional sprinklers installed upright	Spray sprinklers (upright and pendent types) and conventional sprinklers installed pendent
100	-	17
200	17	40
400	34	100
600	51	200
800	68	300
1000	90	415
1200	135	460
1400	200	460
1600	265	460
1800	340	460

NOTE – This table is to be read in conjunction with Figure 16.

6.4.5 Columns

Sprinklers shall be spaced well clear of columns. Where individual sprinklers are placed within 600 mm of any column, the obstruction to the distribution of water from that sprinkler shall be compensated for by placing a sprinkler within 1.8 m of the opposite face of the column.

6.4.6 Girders

Sprinklers shall be not less than 1.2 m from any girder with a top flange exceeding 200 mm nominal width. Where the top flange of a girder does not exceed 200 mm nominal width, the sprinklers may be located directly over the girder, provided that the sprinkler deflectors are not less than 150 mm above the top of the girder.

6.4.7 Roof trusses

Sprinklers shall be not less than 300 mm laterally from truss members which are 100 mm nominal or less in width. Where widths exceed 100 mm nominal, the sprinklers shall be not less than 600 mm laterally therefrom.

Where range pipes pass above or through trusses, the sprinklers may be located on the centreline of the truss if the truss members are not more than 200 mm nominal in width and the sprinkler deflectors are 150 mm above the truss member. When sprinklers are located alongside truss members, the distance of the sprinkler deflectors therefrom shall be in accordance with Table 8.

6.4.8 Clear space below sprinklers (see also 12.1.3.4 and 12.1.3.5)

A clear space not less than 500 mm (except for those locations in 6.6 where supplementary protection is required) shall always be maintained below the level of the sprinkler deflectors throughout the room. For high piled combustible stock, clearance not less than 1 m shall be provided. Roof trusses shall at all times be accessible to water discharged from the sprinklers. Where sloping ceilings or roofs are concerned, stored goods may follow the slope, provided that the above clearances are maintained.

6.5 Spacing and location of sidewall sprinklers

6.5.1 General

The following requirements shall apply to the spacing and location of sidewall sprinklers:

- The sprinklers (see 7.2.1 (d)) shall be mounted with their deflectors not more than 150 mm and not less than 100 mm from the ceiling;
- The centreline of the sprinklers shall be not less than 50 mm and not more than 150 mm from the wall face on which they are mounted;
- There shall be no obstruction at the ceiling within an area extending along the wall 1 m on each side of a sprinkler and 1.8 m at right angles to the wall;
- Beams on any boundary of this area shall not exceed a depth of 100 mm;
- If sprinklers are mounted closer to beams than the distances specified in Table 9, the bays formed shall be separately protected.

Table 9 – Distance from sidewall sprinklers to beams

Maximum depth of beam mm	Minimum distance from sprinkler to side of beam, m	
	In direction at right angles to wall	In direction parallel to wall
100	1.8	1.0
125	2.1	1.2
150	2.4	1.5
175	2.7	1.6
200	3.0	1.8

6.5.2 Maximum spacing of sidewall sprinklers

The spacing of sidewall sprinklers along the walls and from end walls shall be appropriate to the hazard class (see 10.4 or 11.3).

6.5.3 Distance between rows of sprinklers

The distance between rows of sprinklers shall comply with the following requirements:

- Rooms not exceeding 3.7 m in width shall have a minimum of one row of sprinklers along the length of the room;
- Rooms exceeding 3.7 m but not exceeding 7.4 m in width shall have one row of sprinklers at each side along the length of the room;
- In rooms exceeding 7.4 m in width, conventional, spray or ceiling type sprinklers shall be provided centrally positioned under the ceiling to supplement the sidewall sprinklers;
- In rooms exceeding 9.2 m in length (light hazard) or 7.4 m in length (ordinary hazard), the sprinklers shall be regularly staggered so that the sprinklers face midway between the sprinklers on the opposing wall.

6.6 Locations or conditions involving special consideration (supplementary protection)

6.6.1 Roof spaces

NOTE – Roof spaces shall mean all concealed spaces between ceilings and roofs measured between the underside of the outer-roof covering to the top of the lined ceiling.

6.6.1.1 Roof spaces not exceeding 400 mm in depth need not be protected by sprinklers.

6.6.1.2 Roof spaces exceeding 400 mm but not exceeding 800 mm in depth shall be protected by sprinklers installed on the basis of light hazard group in accordance with clause 10 of this standard, except that the sprinkler protection may be omitted where the space is subdivided by fire and draught stops at intervals not exceeding 15 m in each direction.

6.6.1.3 Roof spaces exceeding 800 mm in depth shall be fully protected by sprinklers in accordance with the requirement for the particular hazard.

6.6.2 Concealed ceiling and floor spaces

NOTE 1 – Ceiling and floor spaces shall mean all concealed spaces between floors (or concrete slab roofs and floor) measured between the underside of the floor (or concrete slab roof) to the top of the lined ceiling or between the top of the floor to the underside of the raised floor.

NOTE 2 – For waffle type concrete slabs not exceeding 1.5 m², the depth may be measured from the soffit of the waffle beams to the top of the lined ceiling.

NOTE 3 – Air conditioning and mechanical ventilation ducts constructed in accordance with the requirements of SS CP 13 shall be deemed to be non-combustible.

6.6.2.1 Concealed ceiling and floor spaces not exceeding 400 mm in depth need not be protected by sprinklers.

6.6.2.2 Concealed ceiling and floor spaces exceeding 400 mm but not exceeding 800 mm in depth and not containing combustible materials need not be protected by sprinklers.

6.6.2.3 Concealed ceiling and floor spaces exceeding 400 mm but not exceeding 800 mm in depth and containing combustible material shall be protected by sprinklers installed on the extended basis as specified in 6.6.1.2 except that the sprinkler protection may be omitted where the space is subdivided by fire and draught stops at intervals not exceeding 15 m in each direction.

NOTE – In the case of public buildings, except offices, all concealed ceiling spaces exceeding 400 mm but not exceeding 800 mm in depth, regardless of the nature of contents, shall be protected by sprinklers installed on the extended basis as specified in 6.6.1.2.

6.6.2.4 Concealed ceiling and floor spaces exceeding 800 mm in depth not containing combustible materials shall be protected by sprinklers installed on the extended basis as specified in 6.6.1.2.

6.6.2.5 Concealed ceiling and floor spaces exceeding 800 mm in depth containing combustible materials shall be fully protected by sprinklers in accordance with the requirement for the particular hazard.

6.6.2.6 Piping shall be installed in accordance with the requirements of the particular hazard class.

6.6.3 Machinery pits and production lines

Machinery pits and the underside of production lines, where waste may collect, shall be protected.

6.6.4 Hoists, lift shafts, building services shafts and enclosed chutes

Sprinklers shall be installed in all hoists, lift shafts, service shafts and chutes that are inside or in communication with buildings. The positioning of the sprinklers shall be as follows otherwise as permitted in 4.3.5:

a) Hoists, lift shafts and sheave rooms

Sprinklers shall be installed in the top and base of each hoist and lift shaft. Sprinklers installed in lift shafts and sheave rooms shall be protected by stout metal guards and shall have a temperature rating of not less than 100°C.

b) Building services shafts

Shafts housing air-handling ducts and other building services that are not sealed at each floor level and are provided with access panels or doors shall have sprinklers fitted at vertical intervals of 15 m in addition to that at the head of the shaft.

c) Chutes

Chutes for disposal of refuse, solid linen, and similar, shall have a sprinkler in the head of each chute. Chutes in buildings exceeding two storeys in height shall have a sprinkler fitted at each alternate level in addition to that at the head of the chute.

NOTE – Sprinklers are not required at the top of lift shafts enclosed by walls, ceilings and floors with a fire resistance of not less than two hours, in which all hoistway doors are of not less than one hour fire resistance.

All sprinklers installed in chutes and shafts shall be protected from mechanical damage and shall be fitted, where necessary, with a suitable baffle in order to prevent the first operating sprinkler from wetting the lower sprinklers.

6.6.5 Grain elevators, rope or strap races, gearing boxes and dust receivers (see Figure 17)

A sprinkler shall be fitted in the box at the top of every elevator (other than those of the pneumatic type or which comprise a slow moving endless chain fitted with rings, loops or forks, capable of functioning only when the elevator is full. The sprinkler in each case shall be so placed as to command the head and both legs or shafts of the elevator.

Sprinklers shall be fitted internally in all rope or strap races, enclosed belt or shaft machine drives and gearing box compartments.

Where exhaust fans are installed within ducts conveying dust or refuse, a sprinkler shall be fitted inside the duct immediately downstream of the fan.

To prevent obstruction and mechanical damage, the sprinkler shall be recessed within a purpose-built metal box mounted on the duct.

Sprinklers shall not be installed on the underside of the ducts.

Sprinklers shall be fitted in dust cyclones, collection chambers and boxes where these are:

- a) housed within the protected building;
- b) erected outside and directly above the protected building unless the roof is of noncombustible construction; or
- c) external to but connected with and closely adjacent to the protected buildings.

Where dust cyclones, collection chambers and boxes are erected above non-combustible roofs or where they are situated remote from the protected buildings, at least one sprinkler shall be fitted inside the trunking where it leaves the protected building (see Figure 18).

6.6.6 Corn, rice, provender and oil mills

Sprinklers shall be fitted in corn, rice, provender and oil mills as follows:

- a) Sprinklers shall be fitted not more than 3 m apart inside all dust trunks which are more than 30° from the vertical and constructed of combustible materials;
- b) A sprinkler shall be fitted at the head of every dust trunk;
- c) Where centrifugals or similar machines are placed one above another in tiers as shown in Figure 19 and are less than 1 m from each other, sprinklers shall be fitted in the spaces as shown.

6.6.7 Bins and silos

All bins and silos of combustible construction having a plan area in excess of 9 m² for the storage of flour, bran, or other similar material which has undergone any process of reduction (in such premises as flour mills, granaries, oil mills or distilleries), or for the storage of sawdust, wood flour, pulverised coal and similar easily ignitable materials which can be extinguished by water, shall be internally protected by sprinklers on the basis of one sprinkler per 9 m² of the bin or silo area (see also 11.3.2).

NOTE – If the bin or silo contains materials which will swell if wet and thereby incur the risk of bursting, exemption from this sub-clause may be specially allowed if full particulars are submitted to the relevant authority.

6.6.8 Escalators

Sprinklers shall be fitted under the escalator and in the escalator boot and motor space.

6.6.9 Canopies, external corridors and linkways

With the exception of industrial buildings such as factories, warehouses and storage depots, the following areas are exempted from sprinkler protection:

- a) Areas under canopy, including car porches, provided:
 - 1) Such areas are solely used for the purpose of passenger pickup and drop off;
 - 2) There shall be no commercial activities or storage within these areas;
 - 3) Cut off sprinkler.
- b) External corridors, which do not exceed 4 m in width, provided there shall be no commercial activities or storage within them.
- c) External open-sided linkways, which do not exceed 3 m in width, provided there shall be no commercial activities or storage within them.

In addition, the dividing wall between the canopy and the building need not be separated by any fire rated wall/partition under such canopy.

6.6.10 Roof overhang

Any roof overhang exceeding 1.5 m in width requires sprinkler protection thereunder irrespective of exposure hazard.

NOTE – Exemption from this sub-clause may be allowed if the space under the overhang is not used for storage purposes and subject to the approval of relevant authority.

6.6.11 Exterior docks and platforms

Sprinklers shall be installed under exterior docks and loading platforms of wholly or partially combustible construction, except where such spaces are completely sealed against the accumulation of debris.

6.6.12 Open corridors and verandas

With the exception of industrial buildings such as factories, warehouses and storage depots, the open corridors and verandas not exceeding 3 m in width are exempted from sprinkler protection, provided there shall be no commercial activities or storage within them.

6.6.13 Covered balconies

Covered balconies that exceed 6 m² floor area and have a depth in excess of 3 m shall be sprinklered-protected.

6.6.14 Enclosed paint lines, drying ovens, drying enclosures

Sprinkler protection shall be provided inside enclosed paint lines, drying ovens and drying enclosures. Sidewall sprinklers (see 6.5) may be used for this purpose.

NOTE – Where practicable, sprinklers in ambient temperatures above 70°C should be on a dry pipe system, or the feed pipes thereto should rise up to the sprinklers or groups of sprinklers so as to restrict the thermal circulation of the heated water in the pipes.

6.6.15 Spray booths

Sprinkler protection shall be provided inside spray booths and connected exhaust ducts.

Sprinklers installed within spray booths and connected exhaust ducts shall be protected against the accumulation of residue from spraying operations by a liberal coating of petroleum jelly and paper bags which shall be cleaned off and renewed as often as may be necessary to prevent the formation of a hard deposit on the heads and so preserve the efficiency of the sprinklers. Plastic bags or other protective covering shall not be used for this purpose.

6.6.16 Oil and flammable liquid hazards

Sprinkler protection shall be provided for all oil and flammable liquid hazards.

NOTE 1 – Examples of such hazards include dip tanks and oil-filled electrical transformers.

NOTE 2 – It is recognised that in certain cases modified or supplementary protection may be required where extensive storage, handling or processing equipments such as large dip tanks, varnish kettles, reactors or oil-filled electrical transformers are employed. In these cases medium or high velocity sprayers or other arrangements may be employed in lieu of or in conjunction with sprinklers, provided that adequate water supplies are available and details of the proposed arrangements are first submitted for approval to the relevant authority (see also Table 20).

NOTE 3 – Electrical Supply Authorities may not permit sprinklers in the vicinity of their transformers which are installed on private property.

6.6.17 Air-handling plant

6.6.17.1 Location of sprinklers

In built-up air-handling plants sprinklers shall be located throughout:

- a) the return air/fresh air plenum;
- b) the chambers on each side of any filter bank; and

- c) the fan/motor chamber.

NOTE – See 7.5 for information regarding temperature ratings of sprinklers.

6.6.17.2 Exceptions

Sprinklers may be omitted from air-handling plants which have an external plan area less than 12 m² and an external height less than 2 m.

Sprinklers shall not be installed in fan/motor chambers through which spill air is designed to pass under fire conditions in accordance with CP 13.

6.6.18 Computer data processing center/server room

Sprinkler protection shall be provided in areas where computers are installed. The space beneath any false floor which exceeds 250 mm in depth shall be protected on the extended basis of light hazard group in accordance with clause 10 of this standard.

NOTE – Where heavy concentrations of cables are located in the space beneath a false floor which does not exceed 250 mm in depth, every effort should be made to provide full sprinkler protection to the space.

Other forms of automatic extinguishing systems in place of the sprinkler system may also be provided subject to the approval of the relevant authority.

6.6.19 Atriums

With the exception of industrial buildings such as factories, warehouses and storage depots, the atrium roofs exceeding 12 m in height are exempted from sprinkler protection. In lieu of sprinklers, approved effective detectors (e.g. smoke, infra-red, etc) are to be installed in accordance with approved standards and there shall be no commercial activities or storage within the floor space below the atrium roofs.

6.7 Obstructions below sprinklers

6.7.1 General

Where obstructions below sprinklers are such that the operation of sprinklers could be delayed or effective distribution of water from the sprinklers could be impaired, sprinklers shall be mounted below such obstructions in accordance with 6.7.2 to 6.7.7.

6.7.2 Overhead platforms

Sprinklers shall be installed below internal overhead platforms, heating panels, galleries, walkways, stagings, stairs and stairways and chutes exceeding 800 mm wide and closer than 150 mm to adjacent walls.

If the clearance from adjacent walls exceeds 150 mm, sprinklers shall be fitted below any such structure which exceeds 1 m in width.

6.7.3 Suspended open grid ceilings

Suspended open ceilings are ceilings having a regular open cell construction recurring throughout their design. They are usually fitted for aesthetic purposes, but when positioned below a sprinkler system must not prevent its effective operation.

Suspended open ceilings may be permitted beneath light and ordinary hazard sprinkler systems not involving storage areas.

The suspended open ceilings and sprinkler arrangement must comply with the following requirements:

- a) Suspended open ceilings shall preferably be of non-combustible construction and shall not be liable to collapse before operation of sprinklers. The ceiling shall be suspended on non-combustible supports, and the materials shall not cause dripping of molten particles in fire conditions.
- b) The structural integrity of the suspended open ceilings and any other equipment, such as light fittings within the volume above the suspended open ceilings, shall not be affected by operation of the sprinkler system.
- c) The total plan open area of the suspended open ceiling shall not be less than 70% of the ceiling plan area. Services installed in suspended open ceilings, such as light fittings, shall not reduce the open plan area of the ceiling below 60% of the total ceiling plan area. Supplementary sprinklers shall be provided to discharge below light fittings or similar obstructions exceeding 800 mm width.
- d) The minimum dimension of the openings shall not be less than 25 mm or the vertical thickness of the suspended ceilings, whichever is the greater.
- e) The sprinkler spacings above suspended open ceilings shall not exceed 3.0 m maximum with an area of coverage not exceeding 9 m² maximum. Where these sprinkler spacing requirements cannot be met in existing installations, the relevant authority must be consulted.
- f) The vertical separation between any sprinkler deflector and the top of the suspended ceiling shall not be less than 800 mm.
- g) Wherever obstructions within the ceiling void are likely to cause significant interference of the water discharge they should be treated as walls for the purpose of sprinkler spacing.

6.7.4 Ducts

Sprinklers shall be installed under rectangular ducts exceeding 800 mm in width and under circular ducts exceeding 1 m diameter unless there is at least 150 mm clearance from adjacent walls in which case the width without protection may be 1 m and 1.2 m respectively.

Where a duct is erected with the top of the duct less than 500 mm below the ceiling or roof, it shall be regarded as a beam and the requirements of 6.4.4 and 6.5 shall apply (see also 6.4.8).

6.7.5 Suspended ceilings

Sprinklers shall be installed below suspended ceilings (as, for example, in connection with diffused lighting) except where the ceiling construction has been shown to the satisfaction of the relevant authority not to impair the effective water distribution from the sprinklers above.

6.7.6 Hoods over papermaking machines

The underside of hoods or shields over the dry ends of papermaking machines shall be sprinkler-protected. Sidewall sprinklers (see 6.5) may be used for this purpose.

6.7.7 Storage racks

Sprinklers shall be fitted in such positions as to afford efficient protection to goods stored in racks. (see 12.1.3)

6.7.8 Storage fixtures of solid and/or slatted shelved construction

Storage fixtures wider than 2 m shall be fitted with sprinklers at each shelf level.

Storage racks and fixtures wider than 1.2 m but not wider than 2 m shall be:

- a) fitted with sprinklers to the satisfaction of the relevant authority; or
- b) fitted with bulkheads which divide the fixture into areas not exceeding 9 m², with the distance between bulkheads not exceeding 6 m, provided that the total storage height does not exceed the values given in Table 21(B).

Such bulkheads shall be tight partitions extending from front to rear faces and from top to bottom of the storage spaces. They shall be constructed from one of the following materials:

- 1) 15 mm tongued and grooved timber;
- 2) 13 mm hardboard;
- 3) 16 mm chipboard;
- 4) 7 mm flexible fibre cement sheeting; or
- 5) 0.6 mm steel sheet.

NOTE – Sprinkler protection may also be required for work tables, the undersides of which are used for the housing of motive power, or under which process waste of combustible nature may accumulate.

6.8 Film and television production studios

6.8.1 Overhead platforms and walkways

Sprinklers shall be fitted on the underside of overhead platforms or walkways including those for lighting or other equipment, whether slatted or not, together with stairs thereto, if they exceed 800 mm in width, provided that this shall not apply to temporary platforms in connection with sets.

6.8.2 Concealed spaces and cavities

Concealed spaces or cavities between walls and combustible linings, which exceed 100 mm in width, and those between roofs and combustible linings, which exceed 100 mm in depth, shall be fitted with sprinklers.

Electric cables are permitted, provided that the wiring is either in screwed steel conduit or in mineral-insulated metal-sheathed cable.

6.9 Theatres and music halls (protection on the stage side of the proscenium wall)

In addition to the normal sprinkler protection of the roof, sprinklers shall be placed under the gridiron, under the flies, under the stage and in every portion on the stage side of the proscenium wall.

Where the provision of a line of open drenchers or open sprinklers on a fixed fire curtain is required, the control assemblies shall be of the quick-opening type and shall be located in a readily accessible position. Where the water supply to these open drenchers or sprinklers is taken from the sprinkler system, the pressure and flow requirements shall be added to the normal system requirements.

6.10 Cold storage warehouse

6.10.1 General

Wet type sprinkler systems are permitted to protect cold storage warehouse provided the temperature conditions in the area where the piping is installed are such that there is no danger at any time of the water in the pipes freezing.

Dry pendent sprinklers shall be installed in air circulating system plenums formed by one or more false ceilings within the cold chamber.

NOTE – Where practicable, sprinkler piping should be located in normal temperature conditions above the cold chamber with dry pendent sprinklers connected thereto penetrating into the cold chamber.

Air circulation fans shall be closed down automatically on operation of the sprinkler system.

Sprinklers shall not be installed where there is likelihood of mechanical damage due to movement of goods within the cold store.

6.10.2 Piping within the cold chamber

The following special conditions shall apply where it is necessary to install the piping within the cold chamber, or where it is desired to house the sprinkler piping within a single small cold chamber:

- a) The sprinkler installation in the cold room shall be of the permanent dry type and the maximum number of sprinklers controlled by one dry pipe valve shall not exceed 50. These groups of 50 sprinklers may be installed as tail-end dry systems on the basis of at least one control assembly (wet, dry as circumstances dictate) for each five groups.

Each tail-end system shall be controlled by a subsidiary stop valve (see 9.2.4) and shall be include either a water flow alarm switch or an electric alarm pressure switch (see 9.13.4) to indicate the particular section that is opening. These sectional warning systems are additional to the water motor alarm on the main control assembly. Where there is a series of tail-end systems and one main control assembly operating on the dry principle, care needs to be taken to that the air/ gas pressure on the tail-end system is maintained at not less than the air pressure in the system between the control assembly and the tail-end valves.

Differential dry valves used in tail-end systems connected to an installation operating on the dry principle shall be suitably modified to retain air pressure in the system piping between the main control assembly and the underside of the tail-end dry valves.

- b) Sprinklers installed in an air circulation plenum formed by a false ceiling within the cold chamber may be disregarded when determining the maximum number of sprinklers required under (a) above if the sprinklers are fed from the piping feeding the sprinklers in the cold chamber.
- c) The air supply for charging the sprinkler system shall be taken from the cold chamber from the freezers of lowest temperature or through a chemical dehydrator.

Compressed nitrogen gas in cylinders may be used as a substitute for air but care shall be taken to provide a pressure-reducing valve to reduce the gas pressure to not more than 800 kPa to avoid over-pressurizing the system piping.

NOTE – In these circumstances it is desirable to include a pressure-relief valve set to operate at 900 kPa.

- d) Piping joints shall be of a high standard of gas tightness.
- e) The system shall be provided with a low air/ gas pressure alarm.
- f) Dry pipe valves shall be housed outside the cold chamber in areas where the temperature is maintained above 4°C. Where valves are normally provided with a liquid seal, because of the problem of evaporation and possible ice formation in the piping, the sealing medium shall be a fluid such as propylene glycol.
- g) All piping downstream of the dry valve shall be installed above ground such that it can be readily dismantled and reinstated to permit thorough purging of moisture after operation.

Pipe jointing and hangers shall permit easy removal of the piping and in inspection point shall be provided of entry into the cold chamber. Pipe hangers should permit easy removal of the piping. Changes of direction shall be made by using tees with one branch sealed off instead of elbows. Pipe shall be sloped to drain. (see 8.11)

- h) Notwithstanding the requirements of 3.3.2.3, sprinklers may be installed in either the upright or the pendent position, having regard to the necessity for the sprinkler system to be dismantled for drying out after each operation.

7 Sprinklers, sprayers and multiple controls

7.1 General

Sprinklers, sprayers and multiple controls shall be new and of approved makes and types. They shall not be altered in any respect nor have any type of ornamentation or coatings applied after leaving the product factory except as permitted by 6.6.15 and 7.8.

7.2 Types of sprinklers, sprayers and multiple controls

7.2.1 Standard sprinklers

Systems designed in accordance with clause 10, 11 and 12, shall use standard sprinklers. Sprinklers other than standard sprinklers are included in 7.2.2, special sprinklers.

Standard sprinklers consist of the following (see 2.45):

- a) Conventional pattern;
- b) Spray pattern;
- c) Ceiling (flush) pattern;
- d) Sidewall pattern;
- e) Recessed sprinkler;
- f) Concealed sprinkler;
- g) Dry pendent pattern;
- h) Dry upright pattern.

7.2.2 Special sprinklers

Systems incorporating special sprinklers shall be designed in accordance with the relevant parts of 3.4.3.

Special sprinklers consist of the following (see 2.38):

- a) Extended coverage sprinkler (EC);
- b) Large drop sprinkler (LD);
- c) Early suppression fast response sprinkler (ESFR);
- d) Extra large orifice sprinkler (ELO);
- e) Enlarged orifice sprinkler (EO).

7.2.3 Sprayers

Sprayers in an installation shall be medium or high velocity type. They are special purpose sprayers for use in water spray systems (which may or may not form part of sprinkler systems) intended for the extinguishment or control of fires involving flammable liquids and for the cooling of storage tanks, process plant and exposed structural steelwork against heat from an exposure of fire.

NOTE – These sprayers have directional discharge characteristics to provide direct impingement on to the protected surface and are available with cone angles ranging from 40 °C to 180°C. A solid discharge cone is produced from the sprayer by internal swirl vanes, tangential velocity swirl, or single orifice and deflector, with the minimum spray discharge pressures ranging from 150 kPa to 350 kPa, thus providing the higher water discharge velocities.

Sprayers are characterised as follows:

a) Medium velocity sprayers are either:

- 1) sealed sprayers with glass bulbs or soldered links or levers as for sprinklers; or
- 2) open sprayers.

They are designed essentially for cooling purposes when dealing with fires involving low flashpoint liquid hazards, e.g. liquefied petroleum gases. In such risks the aim is not for automatic extinguishment but to control the burning within safe limits until the source of gas supply has been shut off, thus avoiding the danger following a fire incident of these heavier than-air gases continuing to escape and collecting in low-lying areas producing an explosion hazard.

b) High velocity sprayers are of the 'open' type and are designed for the extinguishment of fires involving high flashpoint liquids.

7.2.4 Multiple controls

Multiple controls are heat-sensitive sealed valve controlled outlets (single or multiple) using either glass bulbs or soldered links or levers as the heat-sensitive device. They are designed for use in systems using medium velocity or high velocity sprayers of the 'open' type in circumstances where it is required to operate small groups of sprayers simultaneously. They may also be used in connection with bypass piping for alarm purposes. The controls are made in various sizes relevant to the diameter of the valve and the number of sprayers that are to be fed therefrom. The sizes range from 20 mm to 80 mm.

7.3 Sprinkler K factors, orifice and thread sizes

Sprinklers shall have the K factors, nominal orifice sizes, and nominal pipe thread sizes set out in Table 10.

Table 10 – Sprinkler K factors, orifice and thread sizes

Hazard class	Nominal size of orifice mm	K factor ^a	Nominal pipe thread size ^b mm
Light only	10	5.7 ± 5%	10
Ordinary and high	15	8.0 ± 5%	15
High only	20	11.5 ± 5%	20
^a The K factor is the constant in the formula $Q = K\sqrt{P}$ where Q = flow, in litres per minute P = pressure, in kilopascals.			
^b The nominal pipe thread sizes are stipulated to avoid the possibility of inadvertent interchange between the sprinklers of different orifice sizes.			

7.4 Application of sprinkler types

The types of sprinkler for the appropriate hazard class shall be limited to those nominated in 10.4.1.1, 11.4.1.1 and 12.4.1.1.

7.5 Temperature ratings

The temperature ratings chosen shall be not less than 30°C above the highest anticipated temperature conditions except that:

- Under glazing, translucent plastics and uninsulated metal roofs, in unventilated concealed spaces and show windows on external walls, and in other locations which are directly exposed to the sun, it may be necessary to install sprinklers with a temperature rating between 79°C and 100°C;
- In high hazard systems protecting high piled storage, sprinklers having a nominal temperature rating of 141 °C shall be used at the roof or ceiling;
- Where high temperature sprinklers are installed within drying ovens or hoods over papermaking machines and the like (see 6.6.14 and 6.7.5), sprinklers at the ceiling or roof immediately over and to a distance of 3 m beyond the boundary of such structures should be of the same temperature rating, subject to a maximum of 141 °C.

NOTE 1 – Sprinklers are approved in nominal temperature ratings ranging from 57°C to 260°C (see Table 11).

NOTE 2 – For normal conditions, ratings of 68°C to 74°C will be generally suitable.

7.6 Colour coding

The colour code given in Table 11 shall be used to distinguish sprinklers of different nominal temperature ratings.

Table 11 – Colour coding of sprinklers

Sprinkler type	Temperature rating °C	Colours of yoke arms	Colour of bulbs
Soldered and fusible chemical	68-74	Uncoloured	-
	93-100	White	-
	141	Blue	-
	182	Yellow	-
	227	Red	-
Glass bulb	57	-	Orange
	68	-	Red
	79	-	Yellow
	93	-	Green
	141	-	Blue
	182	-	Mauve
	204-260	-	Black

7.7 Stock of replacement sprinklers

A stock of spare sprinklers, with the necessary spanners, shall be maintained on the premises so that any sprinklers that have operated or have been damaged in any way can be promptly replaced.

The spare sprinklers and spanners shall be kept in an accessible designated position.

NOTE 1 – The number of spare sprinklers to be maintained on the premises will depend on the hazard class of the system and the types and temperature ratings of the sprinklers installed. As a general guide the following number of spares of standard temperature ratings should be:

- | | | |
|----|------------------------|---------------|
| a) | Light hazard system | 6 sprinklers |
| b) | Ordinary hazard system | 24 sprinklers |
| c) | High hazard system | 36 sprinklers |

NOTE 2 – Should the systems include sprinklers of high temperature ratings, eg. in boiler rooms or drying ovens. An adequate number of spare sprinklers of the appropriate temperature rating should also be maintained. Similarly if the systems include sidewall or other special type sprinklers or if there are any multiple controls, an adequate number of spares should be maintained.

NOTE 3 – Spares should be replenished immediately after an incident. Advice should be sought regarding the possible necessity of replacing sprinklers, on the perimeter of the area, which although they have not operated, may have been heat affected.

7.7.1 Special sprinklers

Where special sprinkler systems are installed, a stock of spare special sprinklers, suitable for the purpose, shall be kept on the premises.

7.8 Anti-corrosion treatment of sprinklers

Sprinklers used in bleach, dye and textile print works, alkali plants, organic fertiliser plants, foundries, pickle and vinegar works, electroplating and galvanizing works, paper mills, tanneries and in any other premises or portions of premises where corrosive vapours are prevalent shall have approved corrosion-resistant coatings or shall be coated twice with a good quality petroleum jelly, the first coat to be applied before installation and the second after installation. These latter coatings shall be renewed at periodic intervals as may be necessary (see AS 1851 : Part 3), but only after the existing coatings have been thoroughly wiped off. For glass bulb type sprinklers, the anti-corrosion treatment need only be applied to the body and yoke.

7.9 Sprinkler guards

In situations where sprinklers are liable to damage, or where otherwise specified by the relevant authority, sprinklers shall be protected by approved metal guards. Guards shall not be used in conjunction with flush, recessed or concealed-type sprinklers.

7.10 Escutcheon plates assemblies

Escutcheon plate assemblies fitted to sprinkler shall be of metal and securely attached so that they cannot slip down and adversely affect activation of the water discharge pattern of sprinklers.

Recessed escutcheon plate assemblies shall only be used with sprinklers that have been listed for such mounting (see 7.2.1(e)).

7.11 Protection against frost

Sprinkler heads shall not be wrapped or enclosed in any material for protection against frost.

8 Piping

8.1 Pipe and pipe fitting specifications

8.1.1 General

All pipes and pipe fittings in an installation shall be new and shall comply with one or other of the following standards or equivalent:

- a) AS 1159 Polyethylene (polythene) pipe for pressure applications;
- b) AS 1432 Copper tubes for water, gas and sanitation;
- c) AS 1567 Wrought copper and copper alloy rods, bars and sections for general engineering purposes;
- d) AS 1724 Cast grey iron pressure pipes and fittings with bolted gland joints;
- e) AS 1769 Welded stainless steel tube for plumbing applications;
- f) AS 1835 Seamless steel tubes for pressure purposes;
- g) AS 1836 Welded steel tubes for pressure purposes;
- h) AS 2544 Grey iron pressure pipes and fittings;
- i) SS17 Steel tubes suitable for screwing to BS 21 pipe threads;
- j) SS142 Steel pipes, fittings and specials for water, gas and sewerage.

NOTE 1 – Pipes and fittings which are connected directly to the PUB mains supply shall comply with the standards and requirements stipulated by Water Department, PUB.

NOTE 2 – All pipes in an installation shall not be lined with any bituminous based or plastic material.

8.1.2 Pipes above ground

Pipes above ground shall be at least equivalent to medium grade steel tube complying with the requirements of:

- a) SS 17; or
- b) AS 1835 or AS 1836, subject to a minimum thickness of 4.76 mm.

Pipes above ground and downstream of the main control valve shall be at least equivalent to medium grade black steel tube in accordance with the requirements of the foregoing paragraph.

8.1.3 Pipes below ground

Pipes laid underground shall comply with the relevant standards listed in 8.1.1.

Cast iron pipes and fittings complying with AS 1724 and AS 2544 shall be coated and cement mortar lined in accordance with AS 1281 or AS 1516.

Pipes complying with SS 17, SS 142, AS 1835 and AS 1836 shall be subject to a minimum wall thickness of 5.3 mm.

8.1.4 Protection of underground pipes

Underground pipes shall be protected against corrosion where necessary and shall not be laid in positions where there could be damaged by vehicular traffic.

8.1.5 Pipe risers and downcomers

Shafts housing sprinkler pipe risers and downcomers through floor shall not contain flammable liquid and gas pipes and any other installations which are fire hazardous.

8.2 Hydraulic test pressure

All new installations, trunk mains and water supply connections of a sprinkler system shall be capable of withstanding for a period of 2 h a hydraulic test pressure of 1.4 MPa, or 400 KPa in excess of the maximum static working pressure, whichever is the greater.

8.3 Pipe jointing

8.3.1 Welded pipes

Only pipes of 50 mm diameter or greater may be joined by welding unless the joints are fabricated, welded and inspected in the workshops.

On-site welding operations should be avoided as far as possible, but if unavoidable they shall be carried out in accordance with AS 1674.

8.3.2 Mechanical rolled grooved couplings

Pipes joined with grooved fittings shall be joined by a listed combination of fittings, gaskets and grooves.

Grooves cut or rolled on pipes shall be dimensionally compatible with fittings.

Grooved fittings including gaskets used on dry pipe systems shall be listed for dry pipe service.

8.4 Embedding of piping

Sprinkler piping must not be embedded in concrete floors or any other surfacing material of a building.

NOTE – Embedding of piping is prohibited for two principal reasons:

- a) problems of corrosion; and
- b) difficulties of making subsequent alterations to the pipe systems.

8.5 Corrosion protection of piping

Sprinkler piping installed in an aggressive environment shall be suitably protected against corrosion.

NOTE – In bleach, dye and textile print works, paper mills, tanneries and in other premises where corrosive conditions exist, piping should be thoroughly cleaned and protected by suitable means, e.g. two coats of good quality, bituminous paint one coat being applied before and one after erection. While this treatment will materially lengthen the effective life of the pipes, it will probably be found necessary to renew the coatings from time to time at intervals from 1 year to 5 years according to the severity of the conditions. As an alternative to the above treatment:

- a) galvanised pipes may be employed, provided that the threaded ends of the pipes are adequately sealed with a suitable protective coating, eg. bituminous paint; or
- b) the pipes may be wrapped in a suitable protective tape.

8.6 Piping in unsprinklered buildings

With the exception of concealed spaces not requiring protection as permitted in 6.6, sprinkler piping shall not pass through buildings or areas not protected by sprinklers unless it is enclosed by a construction having a fire resistance rating of not less than 2 hours.

NOTE – See also 8.8 regarding special precautions for piping, valve fittings, etc: in buildings or sections of premises in which particularly hazardous processes are carried out or conditions exist which are liable to result in explosions.

8.7 Protection of piping against mechanical damage

Sprinkler piping shall be protected against mechanical damage.

NOTE – Sprinkler piping should not be erected in locations where it is liable to damage by forklift trucks and other mobile equipment; in particular, it should not cross gangways where such equipment is used unless the headroom is in excess of the height of the equipment concerned. Where it is impracticable to avoid areas subject to such traffic, the piping should be protected by adequate guards. Where installation valves or risers are situated in such areas, in addition to guardrails, safety guidelines should be marked out

8.8 Hazardous processes and explosion hazard – Special precautions concerning piping and valves

In buildings or sections of premises in which protection from explosion is required, the following special precautions shall be taken:

- a) Separate control assemblies shall be provided to control the sprinklers and shall be located either:
 - 1) in a structure separated from the hazardous building by a distance not less than 6 m; or
 - 2) where this is not practicable, in an enclosure separated from the hazardous building by imperforate concrete or masonry walls and/or roof with a fire-resistance rating of not less than 2 hours. Where this enclosure is recessed in an external wall of the building which does not have a fire-resistance rating, a return wall 3 m long and the same height as the enclosure, with a fire-resistance rating not less than 2 hours, shall be provided on each side. Sole access to the valve enclosure shall not be through the hazardous area.
- b) Trunk mains leading to and from such installation shall be either carried external to the building concerned or adequately protected from damage arising from building collapse following an explosion (see 8.6).
- c) Water supplies such as pumps or gravity tanks shall not be housed therein.

8.9 Facilities for flushing piping

Where the water supplies include an automatic pump drawing from a source of non-potable water, such as a canal, river or lake, flushing connections shall be provided at the extremities of distribution pipes.

8.10 Prohibited use of piping

8.10.1 Electrical earth

Sprinkler pipes shall not be used as a means of earthing an electrical installation or as a link in an earthing circuit.

8.10.2 Hoisting

Sprinkler pipes shall not be used for hoisting or supporting other services nor shall articles be hung from them.

8.11 Slope of pipes for drainage

Sprinklers forming part of dry pipe system shall be so installed that the system can be thoroughly drained. Range piping shall have a slope of not less than 4 mm in 1 m, and distribution piping shall have a slope of not less than 2 mm in 1 m.

NOTE – Piping in all systems including piping in wet pipe systems should be arranged to drain to the installation drain valve which should be not less than 50 mm in diameter for ordinary and high hazard systems and not less than 40 mm in diameter for light hazard systems.

8.12 Low level drainage

In basements and other areas where sprinkler piping is below the installation drain valves and in other trapped sections in the system, auxiliary drain valves of the following minimum sizes shall be provided:

- a) For pipes up to 50 mm diameter – 20 mm
- b) For 65 mm diameter pipes – 25 mm
- c) For pipes larger than 65 mm diameter – 32 mm

8.13 Pipe sizes

Pipe sizes shall be determined either by full hydraulic (see clause 13), or partly by pre-calculated pipe size tables and partly by hydraulic calculations in accordance with the requirements for the class of hazard (see 10.4.2, 11.4.2 and 12.4.2).

8.14 Orifice plates

Orifice plates fitted to assist in hydraulically balancing a high hazard class system or to meet pump characteristic curves shall have an orifice diameter of not less than 50 percent of the diameter of the pipe into which the plate is to be fitted and shall comply with the requirements of Annex A. Such orifice plates shall be permitted only in pipes 50 mm diameter or larger.

The relationship between the size of the orifice, the flow and pressure loss, shall be calculated in accordance with Annex A.

8.15 Support of sprinkler piping

8.15.1 General

When a pipe support system is being designed for an automatic fire sprinkler system, consideration shall be given to the correct location of pipe supports and to:

- a) the stresses and loads which may be imposed on the support system from all external causes including differential movement of the building structure and all internal causes including pressure reactions;
- b) the transmission of vibration from the building to the piping and from the piping to the building;
- c) the effect a corrosive atmosphere may have on the materials used (see also 8.5); and
- d) the isolation of the pipe from the support when unlike materials are used.

8.15.2 Design

The piping associated with automatic fire sprinkler systems shall be adequately supported by either:

- a) a pipe support system, the individual components of which comply with the requirements of 8.15; or
- b) pipe supports and fasteners which are designed to support two times the mass of the piping filled with water plus a load of 115 kg at each point of support.

In addition to providing support for the piping, pipe support systems shall be designed to prevent sway in the piping.

NOTE – BS 3974 provides further guidance on types of pipe supports.

8.15.3 Materials

Except where otherwise approved, components of pipe supports shall be of ferrous material.

8.15.4 Requirements for pipe support components (see Figure 20)

8.15.4.1 Hook bolts

The following requirements apply to the use of hook bolts:

- a) Hook bolts shall not be used as hangers.
- b) Hook bolts shall not be threaded along their full length.
- c) Hook bolts shall not be used for clamping up piping exceeding 50 mm nominal internal diameter.
- d) Hook bolts shall not be used for piping exceeding 80 mm nominal internal diameter.
- e) Hook bolts shall conform to the following dimensions:

Pipe size mm	Minimum nominal diameter of material	
	Clamping down mm	Clamping up mm
Up to 50	8	10
Over 50 up to 80	10	-

NOTE – The arms of hook bolts should be located on alternate sides along a length of pipe.

8.15.4.2 U-bolts clamping down

U-bolts used for clamping down shall conform to the following dimensions:

Pipe size mm	Minimum nominal diameter of material mm
Up to 50	6
Over 50 up to 150	10
Over 150 up to 250	12
Over 250 up to 350	15

8.15.4.3 U-bolts clamping up and rods

U-bolts used for clamping up and rods supporting piping shall conform to the following dimensions:

Pipe size mm	Minimum nominal diameter of material mm
Up to 50	6
Over 50 up to 150	12
Over 150 up to 250	15
Over 250 up to 350	20

8.15.4.4 U-hangers (clips)

U-hangers shall conform to the following dimensions:

Pipe size mm	Nominal size of material mm
Up to 40	1.6 x 25
Over 40 up to 65	3 x 25
Over 65 up to 150	6 x 30

NOTE – Where used on range pipes, U-hangers are commonly referred to as 'range clips'.

8.15.4.5 Cantilever type supports

Cantilever type supports shall be manufactured such that no material is less than 6 mm thick and the support and fixings shall be designed to support two times the mass of the pipe filled with water plus 115 kg applied at the support.

8.15.4.6 Saddle brackets and girder or beam clamps

Saddle brackets and girder or beam clamps of the design illustrated in Figure 20(e)(i) shall be fabricated from material not less than 6 mm thick and not less than 30 mm wide. For a saddle bracket, the distance between the centres of the fixing holes shall not exceed 240 mm. For a girder or beam clamp, the distance from the edge of the supporting member to the centre of the rod shall not exceed 80 mm.

Girder or beam clamps of the design illustrated in Figure 20(e)(ii) shall be fabricated from material not less than 3 mm thick and not less than 25 mm wide.

8.15.4.7 Pipe bands

Pipe bands shall be fabricated from material complying with the following requirements:

- a) For non-corrosive atmospheres:

Pipe size mm	Minimum material thickness mm
Up to and including 100	1
Over 100	3

- b) For corrosive atmospheres: not less than 3 mm thick

8.15.4.8 Pipe support beams (trapeze bar)

Pipe support beams shall be fabricated:

- a) from material with section modulus equal to or greater than those calculated from the sections detailed below; or

- b) using mild steel angle, conform to the following dimensions:

Pipe size mm	Nominal size of material	
	Maximum span 2 m mm	Maximum span 3 m Mm
Up to 40	40 x 40 x 6	65 x 40 x 6
Over 40 up to 65	65 x 40 x 6	75 x 50 x 6
Over 65 up to 150	100 x 65 x 8	100 x 75 x 8

Where unequal angle is used, the longer arm shall be vertical.

8.15.5 Fixing of pipe supports

8.15.5.1 General

Sprinkler piping may be supported from the building structure, provided that the structure is capable of supporting the load. Where sprinklers are located below ducts, the piping may be supported from the duct supports, provided that these have sufficient strength to support the combined design load.

Sprinkler piping shall be supported independently of ceiling sheathing and any associated suspension system.

8.15.5.2 Fixing to concrete, brick or masonry

Wooden plugs or plugs of plastic material shall not be used for fixing pipe supports to concrete, brick or masonry. Explosive-powered fasteners (see AS 1873), wooden plugs or plugs of plastics material shall not be used for fixing pipe supports to concrete, brick or masonry, through-bolts, expanding metal fasteners or bolts or screws set in concrete may be used in this type of construction for fixing pipe supports. The fixing shall be capable of supporting the design load specified in 8.15.2(b).

8.15.5.3 Fixing to timber

Explosive-powered fasteners may be used for fixing pipe supports to timber, provided that the timber is not less than 40 mm thick. Other acceptable methods of fixing to timber are wood screws, drive screws, coach screws and coach bolts. Nails shall not be used for fixing pipe supports to timber.

The following requirements shall apply:

- Wood screws shall not be hammer driven.
- Drive screws shall not be used for securing upwards.
- Wood screws or drive screws shall not be used for fixing piping exceeding 50 mm nominal diameter.
- The fixing shall be capable of supporting the design load specified in 8.15.2(b).

- e) Coach bolts and coach screws shall conform to the following minimum dimensions:

Pipe size mm	Nominal diameter of coach bolt or coach screw mm	Nominal length of coach screw mm
Up to 50	6	50
Over 50 up to 150	12	75
Over 150 up to 200	15	75

8.15.5.4 Fixing to steel

Explosive-powered fasteners may be used for fixing pipe supports to steel, provided that the steel is not less than 5 mm thick. The fixing shall be capable of supporting the design load specified in 8.15.2(b).

8.15.6 Spacing of supports

The distance between supports for horizontal and vertical sprinkler piping shall not exceed the following:

Pipe size mm	Maximum spacing m
Up to 25	4
Over 25 up to 100	5
Over 100	6

In certain types of construction, in which the minimum spacing required cannot be achieved by supporting pipes from main structural members, provision shall be made to support the centre of the span. A typical method is shown in Figure 21.

8.15.7 Location of supports

8.15.7.1 General

Pipe supports shall be located such that they do not obstruct the distribution of water from any sprinkler head.

8.15.7.2 Change of direction

A support shall be located not further than 1 m from any change of direction in the piping, eg. bend or elbow.

8.15.7.3 Range pipes

Range pipes exceeding 500 mm in length shall have at least one support. The first support on any range pipe shall be not more than 2 m from the distribution pipe or riser (drop). The distance from the last support to the end of a range pipe shall not exceed the following:

- a) For pipes up to 25 mm nominal diameter – 1.0 m
- b) For pipes over 25 mm nominal diameter – 1.5 m

8.15.7.4 Distribution pipes

The first support on any distribution pipe shall be not more than 2 m from the connection to the main distribution pipe. The distance from the last support to the end of any distribution pipe shall not exceed 1 m.

8.15.7.5 Main distribution pipes

The distance from the last support to the end of any horizontal main distribution pipe shall not exceed 1 m.

8.15.7.6 Risers

Main vertical pipes rising (or dropping) from the installation valves, or for linking the piping between levels, shall be supported directly from the structure or by supports on horizontal branch piping from the riser not more than 300 mm from the riser.

8.15.7 Verification of design

Supports which comply with the foregoing requirements of 8.15 shall be deemed to meet the requirements for sprinkler piping support systems.

Where the support system is designed in accordance with the provisions of 8.15.2(b), details of the pipe supports proposed may be required by the relevant authority for approval.

Where the details submitted are considered inadequate, the relevant authority may require a verification test. Where a verification test is required, pipe supports shall be capable of withstanding the following test without failure:

- a) The appropriate load from Table 12 shall be applied without shock for a period not less than 30s.

Table 12 – Verification test loads

Pipe size mm	Test load (nominal) kg
Up to 50	340
65	385
80	475
100	680
125 and 150	1200
Over 150	1750
NOTE - This test is not intended for application in-situ. If applied in-situ, appropriate safety precautions must be taken.	

9 Valves and ancillary equipment

9.1 Installation control valves

Each installation shall be provided with a set of installation control valves and ancillary equipment comprising the following:

- a) A main stop valve (see 9.2.2);
- b) An alarm valve (wet pipe) (see 9.10.1) and/ or an alarm valve (dry pipe) (see 9.10.2);
- c) A water motor alarm and gong (see 9.13 and 4.4);
- d) Alarm equipment for automatic transmission to fire service (see 9.13.3);
- e) Emergency instructions (see 9.9);
- f) A location plate (see 9.8);
- g) A plate, or plates, giving essential information on the installation.

9.1.2 Location of control valve

Installation control valves and ancillary equipment shall be located adjacent or near to 1st storey Fire Command Centre (FCC) or fire fighting lobby or in a protected area where it is readily accessible from the common area.

NOTE – Provision shall be made for closure of all installation control valves, other than drain and test valves, to give a visible and audible alarm in the building command centre or, in the absence of a building command centre, at a place under constant surveillance.

9.2 Stop valves

9.2.1 General

All stop valves (except those fitted by the Water Department, PUB on the branches from a PUB mains) shall be of the outside screw and yoke (OS & Y) type and shall be right-handed, i.e. they shall be so constructed that to close the valve, the spindle shall turn clockwise. The controlling wheels of all stop valves referred to in 9.2.2 and 9.2.3 shall be clearly marked showing in which direction the wheel is to be turned to close the valve.

Alternative to OS & Y valve, butterfly valve which is norm gear operated, head wheel type complete with built-in tamper switch with on-off indicator could also be used.

All valves shall be permanently identified to show their function and normal operating position and shall be installed in readily accessible locations to authorised personnel. All valves on the water supply side of the sprinkler alarm valves shall be subject to the requirements of the Water Department, PUB.

9.2.2 Main stop valves

Water supplies to each sprinkler installation shall pass through a main stop valve. Before passing through the main stop valves, water supplies shall be combined. The main stop valve shall be secured open by a padlocked or riveted strap.

9.2.3 Stop valves controlling water supplies

All stop valves controlling water supplies, except those under control of the Water Department, PUB shall be secured open by a padlocked chain or a padlocked or riveted strap. In the elevated private reservoirs and gravity tanks, the stop valve shall be fixed close to the non-return valve and on the reservoir or tank side thereof.

9.2.4 Subsidiary stop valves

Stop valves subsidiary to the main stop valve, downstream of the alarm valve, apart from the installation drain and test valves, may be used in the following circumstances:

- a) To facilitate the testing of a dry pipe valve when a system is permanently on the dry system;
- b) To control groups of sprinklers in areas not exceeding 100 m² which are exposed to frost conditions;
- c) In connection with flushing facilities (see 8.9);
- d) In connection with outlets at the level of the highest sprinkler, where it is required that periodic running pressure tests be carried out at this level;
- e) In any other circumstances subject to the approval of the relevant authority.

Where subsidiary stop valves are used in the above locations, they shall be padlocked in the open position and suitable auxiliary drainage facilities shall be provided. These subsidiary valves shall be monitored with LED indicator and warning buzzer at Fire Command Centre or in its absence, at the main fire alarm panel.

9.3 Valves at pump installation

9.3.1 Non-return valve

A non-return valve shall be installed in each pump discharge assembly.

9.3.2 Pump isolating valves

Valves shall be installed on the outlet side adjacent to the non-return valve and on the inlet side of each pump, except that butterfly valves shall not be installed on the inlet side. The valve shall be secured by a padlock or reverted strap.

9.3.3 Air release valves

A valve shall be installed to automatically release air from the fire protection pumps which are likely to have air entrapped within the casing or column.

9.3.4 Circulation relief valve

Each pumpset shall be fitted with a circulation relief valve to provide sufficient flow to prevent the pump from overheating when operating with no discharge. Provision should be made for discharge to drain or tank.

The size of circulation relief valve shall be:

- a) not less than 20mm for pumps with a rated capacity not exceeding 9720 L/m;
- b) not less than 25mm for pumps with a rated capacity not exceeding 19 200 L/m.

9.3.5 Pressure setting

The pressure setting for the circulation relief valve shall be below the shut-off pressure at minimum expected suction pressure.

NOTE – This clause does not apply to compression ignition engine driven pumps where engine cooling water is taken from the pump discharge.

9.3.6 Visibility of discharge

Provision shall be made for discharge from the circulation-relief valve to be visible to the operator or by fitting a flow indicator.

9.4 Pressure gauges

9.4.1 General

Pressure gauges shall comply with BS 1780 or AS 1349 and have a dial not less than 100mm in diameter and be graduated in kilopascals.

9.4.2 Discharge pressure gauge

A pressure gauge shall be connected to the pump discharge together with a gauge cock. The gauge shall measure pressure to at least twice the rated pressure of the pump but not less than 1000 kPa.

NOTE – The discharge gauge should be located in a section equal in diameter to, and concentric with, the outlet branch of the pump and at least two diameters downstream of the discharge flange. It should also be located at least two diameters upstream of any bends or divergences in the discharge piping.

9.4.3 Suction pressure gauge

A compound pressure and vacuum gauge shall be connected to the pump suction together with a gauge cock.

NOTE 1 – The suction pressure gauge should be located in a section of equal diameter to and concentric with, the inlet branch of the pump. It should, under normal conditions, be located two diameters upstream of the pump flange inlet. Moreover it shall never be placed:

- a) in a diverging section or within four diameters of straight pipe downstream of the divergence;
- b) within the plane of a bend either in the bend itself or within four diameters downstream from the bend; and
- c) within four diameters of straight pipe following a sudden contraction or other discontinuity of cross-sectional area.

NOTE 2 – If gauges are installed in the inlet and outlet flanges of the pump, then it must be recognised that the algebraic sum of the two gauge readings adjusted to pump datum and after allowance for velocity head at the gauge point, may not be a true indication of the head generated by the pump.

9.5 Flow measuring devices

9.5.1 General

Each pumpset shall incorporate the means for measuring rate of flow. Meters, manometers and similar instruments need not be permanently installed.

9.5.2 Capacity

The flow-measuring device shall be capable of measuring a flow not less than 175 percent of pump rated flow.

9.5.3 Size

The recommended pipe size in which the flow-measuring device is located shall be selected as Table 13.

9.5.4 Discharge

The flow-measuring device shall not discharge into the pump suction.

For supply from static storage, the discharge may be returned to the storage. If returned to storage the discharge shall enter at a point remote from the pump suction point.

Table 13 – Guide to sizes for pipes and associated components in pumpsets

Pump standard rated flow L/m	Nominal size		
	Suction pipe	Discharge pipe	Flow- measuring pipe
420	DN 80	DN 65	DN 50
540	DN 80	DN 65	DN 50
840	DN 80	DN 65	DN 80
1020	DN 100	DN 80	DN 80
1440	DN 125	DN 100	DN 100
2100	DN 125	DN 100	DN 100
2400	DN 150	DN 125	DN 150
3120	DN 150	DN 125	DN 150
3900	DN 150	DN 125	DN 150
4560	DN 200	DN 150	DN 150
4920	DN 200	DN 150	DN 200
6480	DN 200	DN 150	DN 200
7200	DN 250	DN 200	DN 200
8100	DN 250	DN 200	DN 250
8820	DN 250	DN 200	DN 250
9720	DN 250	DN 200	DN 250

NOTE – Sizes may need to be varied to satisfy the flow/head characteristics of selected equipment to be installed to achieve the required system/ installation design requirements and available piping.

9.6 Requirements for pressure maintenance pumps

9.6.1 General

Automatic pressure maintenance pumps (jockey or make-up pumps) are used when it is desirable to maintain a uniform or relatively high pressure on automatic sprinkler system water mains.

9.6.2 General Requirements

The following general requirements shall apply to pressure maintenance pumps:

- Pressure maintenance pumps shall have rated capacities of not less than any normal leakage rate. They shall have a discharge pressure sufficient to maintain the desired automatic sprinkler system standing pressure.
- Pressure maintenance pumps shall be sized to make up the allowable leakage within 10 min. at a rate of flow not exceeding 4 L/min.
- All pressure maintenance pumps shall be fitted with an automatic device to prevent cycling effects due to minor system leakage. The pump shall be capable of starting at least 10 times in an hour.
- A non-return valve shall be installed in the discharge pipe.
- Isolating valves shall be installed in such places as are needed to make the pump non-return valve and other miscellaneous fittings accessible for repair.
- If a pressure maintenance pump has a shut-off pressure exceeding the working pressure rating of the automatic sprinkler equipment, a suitable relief valve shall be installed on the pump discharge to prevent damage to the automatic sprinkler system or the pump.

The power supply to this pump shall be such that failure of this pump does not affect the power supply to main fire pump.

NOTE 1 – An automatic pressure maintenance pump is usually required with automatically controlled pumps.

NOTE 2 – A pressure maintenance pump should preferably not start more often than four times per hour. The starting rate is related to leakage in the system.

Acceptable methods for preventing excessive rates of starting include devices to start the pump on pressure drop and stop it on pressure rise, pressure sensing devices with a hydropneumatic accumulator, and pressure-sensing devices with an overriding timer which will ensure that the pump continues to run for minimum time at each start.

9.7 Identification of control valve

A permanently marked plate indicating the storey(s) and or portion of the building served by each control valve shall be placed adjacent to that valve.

NOTE – Embossed plastic tape, pencil, ink, crayon, etc shall not be considered permanent markings. The plate shall be secured with non-corrosive wire, chain, or other means.

9.8 Location plate

A location plate shall be fixed on the outside of an external wall, as near to the main stop valve as possible, bearing the following words in raised letters or other approved type of letters:

SPRINKLER STOP VALVE INSIDE

NOTE – The words SPRINKLER STOP VALVE should be in letters at least 35 mm high and the word INSIDE in letters at least 25 mm high.

It is recommended that the words be painted white on a red background.

9.9 Emergency instructions

The following instructions together with an appropriate valve arrangement shall be permanently displayed at the control valves:

EMERGENCY INSTRUCTIONS

1. MAKE SURE THAT FIRE IS OUT.
2. CLOSE MAIN STOP VALVE (SHUTTING OFF WATER SUPPLY).
3. OPEN WASTE VALVE (DRAINING INSTALLATION).
4. TELEPHONE¹
5. REMAIN AT VALVES.
IF FIRE RE-OCCURS:
(A) CLOSE WASTE VALVE, AND
(B) RE-OPEN MAIN STOP VALVE.

¹ Name and telephone number of responsible maintenance contractor to be inserted.

9.10 Alarm valves

9.10.1 Alarm (wet pipe) valves

Alarm (wet pipe) valves shall be of an approved type. They shall be fixed on the main supply pipe immediately above the main stop valve and before any connection is taken off to supply any part of the installation.

9.10.2 Alarm (dry pipe) valves

Alarm (dry pipe) valves shall be of an approved type. They shall be fixed on the main supply pipe immediately above the main stop valve and before any connection is taken off to supply any part of the installation.

In dry pipe systems maintained permanently under air pressure, the water motor alarm shall be connected to the atmospheric chamber or the alarm motor auxiliary valve of the alarm (dry pipe) valves.

NOTE 1 – In order to facilitate the carrying out of flow tests when an installation is under air pressure, an additional drain valve, of a size appropriate to the hazard class, may be fitted. Alternatively, a stop valve of approved type may be installed immediately above the alarm (dry pipe) valve (see 9.2.4 (a)).

NOTE 2 – Approved composite alarm valves are dual purpose, i.e. they may be used in either wet or dry systems.

9.10.3 Identification of alarm valves and alarm gongs

In buildings containing more than one installation, each alarm valve and automatic alarm to fire service (see 4.4) shall have a number(s) indicated thereon and the relevant alarm gong (see 4.5) shall bear the same number(s) in bold figures.

9.10.4 Accelerators or exhausters for alarm valves (dry system) (see 3.3.2.3)

These devices, which shall be of an approved type, are designed to accelerate the operation of an alarm (dry pipe) valve. They shall be located as close as possible to the alarm (dry pipe) valve or composite alarm valve. The connection to the device from the system shall be so located that the restriction orifice and other opening parts are not likely to become flooded with priming water or back drainage under normal conditions.

9.11 Pressure-reducing valves

The introduction of pressure reducing valves is not permitted.

9.12 Deluge and pre-action valves

9.12.1 Deluge valves

Deluge valves shall be of approved type.

NOTE – These valves are used to control the water to an array of open sprinklers or sprayers (see 3.3.3) which are required to discharge simultaneously. The valve, normally held closed, is released automatically either by the loss of air pressure from independent piping carrying sprinklers acting as thermal detectors, or by the operation of an approved thermal or smoke detection system. Alarm equipment is normally connected to the outlet piping from the valve so that an alarm is given when water flows into the distribution piping.

9.12.2 Pre-action valves

Pre-action valves shall be of an approved type.

NOTE – These valves are used for either of the following purposes:

- a) To control the water supply to a dry sprinkler installation to prevent water discharge from piping or sprinklers which have suffered mechanical damage. The valve, normally held closed, is released by the operation of a thermal or smoke detection system and is of similar type to the deluge valve described in 9.12.1, but the sprinkler piping will be charged with air under pressure (see 3.3.3).
- b) To admit water to the piping of a dry installation prior to the operation of a sprinkler or sprinklers. The valve may be a standard alarm (dry pipe) valve (which may be fitted with an accelerator). The thermal or smoke detection system is arranged to trip the valve in a similar manner to the operation of an exhaustor.

9.13 Alarm devices

9.13.1 General

Alarm devices shall be of approved type. All systems shall be so arranged that the alarm devices shall respond within 3 minutes of opening the 15 mm test valve (see 4.4 and 4.5).

Electrical alarm transmission shall be installed in accordance with Singapore Standard CP 10.

9.13.2 Local water motor alarms

9.13.2.1 Height above valve

Water motor alarms shall be located not higher than 6 m above the valve(s).

9.13.2.2 Piping finish and size

The piping shall be galvanised.

The size of pipe shall be as follows:

- a) Where the length of the piping to the alarm does not exceed 6 m, it shall be not less than 15 mm nominal diameter.
- b) Where the length of the piping to the alarm exceeds 6 m but does not exceed 25 m, it shall be not less than 20 mm nominal diameter.
- c) Where the length of the piping exceeds 25 m, it shall be not less than 25 mm nominal diameter.

9.13.2.3 Alarm valve not to be bypassed

Except for approved water supply shunt apparatus installed for the purpose of continuous main stop valve supervision, no connection between the water supply piping and water motor alarm shall directly bypass the alarm valve.

9.13.3 Automatic alarm to fire service

Direct fire service alarms shall be initiated by:

- a) a flow of water from the alarm valve through a water motor device;
- b) a flow of water from the valve causing actuation of the pressure switch/flow switch; or
- c) a fall in pressure in the system piping above the alarm valve.

NOTE – Auxiliary alarms may take the form of approved electric flow or pressure switches. They may be incorporated in the system piping above the alarm valves to indicate on a central panel which particular section of the system is operating.

The feed piping for hydraulically operated alarms shall be fitted with lock-open valves.

9.13.4 Pressure switches

Where a pressure switch used to initiate a fire alarm is connected to the pipe leading to the sprinkler alarm motor, the stop valve controlling the flow of water to the sprinkler alarm motor shall be positioned on the alarm motor side of the pressure switch connection. Where an installation is on the dry system, a means shall be employed to ensure that pressure operation of the switch cannot be prevented either in the event of a fire or during the weekly test of the alarm motor. If at any time the fire signal connection is interrupted, e.g. during hydraulic testing, then attention shall be automatically drawn to this fact by the monitoring service.

9.14 Pressure gauges

Pressure gauges shall comply with the requirements of AS 1349 or BS 1780 and shall have scales with graduations as follows:

Maximum scale reading MPa	Maximum graduation interval kPa
1	20
1.6	50
> 1.6	100

NOTE – The maximum scale value of gauges should be approximately 150 % of the known maximum pressure.

Means shall be provided to enable each pressure gauge to be readily removed without interruption to installation water supplies.

Gauges to monitor pressures shall be installed in the system at the following locations:

- a) Immediately above the alarm valve.
- b) Adjacent to the main stop valve, connected to indicate the pressure of each water supply. The connection for such gauge(s) shall be on the supply side of the non-return valve nearest the supply.

NOTE – For multiple installation systems, each subsequent main stop valve, or group of main stop valves, may be fitted with a gauge indicating trunk main pressure only.

- c) On the suction and delivery sides of all pumps.

9.15 Remote test valves

For the purpose of the commissioning and periodic testing, a remote test valve shall be provided on each installation (see Figure 22).

The remote test valve piping shall not be less than 25 mm nominal diameter and shall be taken from the end of a range pipe in the most remote group of sprinklers on the installation.

Where the most remote group of sprinklers is not the highest in the installation, an additional remote test valve shall be connected to the range pipe at the highest level.

The test pipe shall terminate in a smooth bore, corrosion resistant orifice giving a flow equivalent to the smallest orifice sprinkler representative of the installation.

The remote test valve shall be readily accessible, locked shut, and shall be labeled as follows:

SPRINKLER REMOTE TEST VALVE – TO BE LOCKED SHUT

10 Light hazard class systems

10.1 Design data

Light hazard systems shall be fully hydraulically designed to provide a flow of at least 48 L/min from each sprinkler within each hydraulically most unfavorable group of six sprinklers in all parts of the building regardless of the area covered by individual sprinklers.

Each group of sprinklers shall be selected to form, as near as possible, a square with the longest side positioned such that it imposes the greatest hydraulic demand. Except as varied by this section, hydraulic calculation methods shall conform to the requirements of clause 13.

10.2 Water supply

10.2.1 Pressure and flow requirements

The water supply shall be capable of providing the maximum pressure and flow requirements of the system as determined by the full hydraulic calculation methods described in 10.1 and clause 13 for a minimum duration of 30 min.

10.2.2 Minimum capacity of water supplies

The useable water quantity in a reservoir or pump suction tank dedicated as a sprinkler system supply shall be a minimum of calculated flow rate for the most unfavourable six sprinklers for a duration of 30 minutes plus 20%.

The calculated minimum water storage capacity may be reduced by up to a third, provided an automatic inflow to a reservoir or tank is available at all times with sufficient flow to make up the difference within 30 minutes.

10.2.3 Pumps

10.2.3.1 General

Pumps shall comply with the appropriate requirements of 5.10 and 5.11 (see also 5.6).

10.2.3.2 Pumps drawing from pump suction tanks

The performance characteristics of pumps drawing from pump suction tanks shall be as set out in Table 14.

10.2.3.3 Pump suction pipe

The minimum nominal diameter of a suction pipe for pumps shall be 100 mm.

10.2.3.4 Capacity of fuel tank

The capacity of the fuel tank, which shall be kept full, for a compression-ignition engine driven pump shall be sufficient to allow the engine to run on full load for 4 hours (see 5.11.3.3(f)(2)). In addition there shall be kept on hand sufficient fuel to run the engine for a further 6 hours.

10.2.4 Pumpsets

Pumpsets shall comply with the following requirements:

- a) The duty flow and pressure of the pump(s) shall be not less than the flow and pressure calculated in accordance with 10.1.
- b) The maximum flow rate of the pump(s) shall be taken to be 130% of the duty flow rate.

Table 14 – Performance characteristics for automatic pumps drawing from pump suction tanks

1	2	3	4	5
Sprinkler Height ^a M	Nominal rating ^b		Minimum characteristics	
	Pressure kPa	Flow L/min	Pressure kPa ^c	Flow L/min
15	180	680	320	400
			370	225
30	260	800	470	400
			520	225
45	340	900	620	400
			670	225
60	410	1000	770	400
			820	225
75	480	1100	920	400
			970	225

^a Height of highest sprinkler above pump.
^b Pump (including any orifice plates) must comply with the nominal rating within limits of ± 5 percent on flow at the stated pressure.
^c Plus friction loss between pump and control valve.

10.2.5 Proving of water supplies

Water supplies shall be proved in accordance with the requirements of 5.12.

10.3 Spacing of sprinklers

10.3.1 Maximum area coverage per sprinkler

The maximum area coverage per sprinkler shall be as follows:

- a) Sidewall sprinklers – 17 m² (see also 6.5)
- b) Other sprinklers – 21 m²

In certain areas of light hazard occupancies such as attics, basements, boiler rooms, kitchens, laundries, storage areas, workrooms, electronic data processing rooms, air conditioning and building services plant rooms, restaurants and cafes not exceeding 126 m² in area, the maximum area coverage shall be limited to 12 m² per sprinkler and the maximum distance between sprinklers shall be limited to 4.2 m and the maximum distance from walls and partitions shall be 2.1 m.

10.3.2 Maximum distance between sprinklers on range pipes and between adjacent rows of sprinklers

The maximum distance between sprinklers on range pipes and between adjacent rows shall be as follows:

- a) Sidewall sprinklers along the walls – 4.6 m (see also 6.5)
- b) Other sprinklers – 4.6 m

NOTE – See also 10.4.1 for reduced distances for certain occupancies.

10.3.3 Maximum distance from walls and partitions (see also 6.4.2 and 6.5)

The maximum distances of sprinklers from walls and partitions shall be as follows:

- | | | | |
|----|------------------------------------|---|-------|
| a) | Sidewall sprinklers from end walls | – | 2.3 m |
| b) | Other sprinklers | – | 2.3 m |

10.4 System components

10.4.1 Sprinklers

10.4.1.1 Size and pattern

Sprinklers shall have a nominal orifice size of 10 mm and maybe spray pattern, ceiling (flush) pattern or sidewall pattern.

10.4.1.2 Special sprinklers

Notwithstanding the requirements of 10.3, other types of sprinklers may be incorporated in the system. Such systems shall be classified as special systems and shall conform to the additional requirements of 3.4.3.

10.4.2 Piping

10.4.2.1 Pipe sizes

Pipe sizes shall be determined by full hydraulic calculation.

10.4.2.2 Fully hydraulically calculated systems

The piping shall be designed on the basis of individual hydraulic calculation of pipes throughout the system. The calculations shall meet the requirements set out in clause 13 of this code.

10.4.2.3 Sprinklers in concealed spaces

Where sprinkler protection is required by 6.6.1 and 6.6.2, pipe sizes to the concealed space sprinklers shall be determined by full hydraulic calculation methods. Where sprinklers above and below a ceiling share common range or distribution pipes, the flow from sprinklers above and below the ceiling need not be taken cumulatively in determining pipe size. Separate calculations shall be carried out for sprinklers above and below ceiling. The water supply requirements of 10.2 shall satisfy the greater of the calculated hydraulic demands.

10.5 System drainage

All pipes shall be arranged with adequate slope for drainage as specified in 8.11.

NOTE – Piping in all systems including piping in wet pipe systems should be arranged to drain to the installation drain valves which should be not less than 40 mm diameter

11 Ordinary hazard class systems

11.1 Design data

Ordinary hazard systems shall be hydraulically designed to provide an appropriate density of discharge over an assumed area of operation (number of sprinklers likely to operate) in all areas including the hydraulically most unfavorable areas of the protected building.

The design density of discharge and the assumed area of operation shall be as follows:

- a) Design density of discharge – 5 mm/min
- b) Assumed area of operation:
 - Group 1 – 72 m²
 - Group 2 – 144 m²
 - Group 3 – 216 m²
 - Group 3 Special (see Note) – 360 m²

NOTE – This group is an extension of Group 3 occupancies where flash fires are likely, covering somewhat larger areas of operation, such as might be anticipated in connection with preparatory processes in textile mills and certain other risks (for classification of occupancies, see 3.2.3).

11.2 Water supplies

11.2.1 Pressure and flow requirements

Water supplies for ordinary hazard class systems shall comply with Table 15.

Table 15 – Pressure/Flow requirements for ordinary hazard class systems

Occupancy group	Minimum running ^a pressure kPa	Flow rate L/min
1	100	375
	70	540
2	140	725
	100	1000
3	170	1100
	140	1350
3 Special	200	1800
	150	2100

^a The pressure equivalent of the distance in height between the highest sprinkler and the control valve is added to all pressure values when discharging the relevant flows at the control valve. The running pressure is measured at the installation gauge.

11.2.2 Minimum capacity of water supplies

11.2.2.1 Reservoirs and tanks other than pressure tanks

The minimum capacity required for fully hydraulically calculated systems shall be not less than that which will supply the calculated flow requirements of the hydraulically most favorable area of operation for 60 min. For partially pre-calculated systems designed in accordance with 11.4.2.2 and 11.4.2.3, the minimum capacities shall be as specified in Table 16. These capacities relate to stored water sources entirely reserved for the sprinkler system (including fire hose reels). For pump suction tanks these capacities may be reduced in accordance with 11.2.2.2, but the maximum period of inflow shall be 1 hour.

NOTE – Where a private carpark is strictly incidental to an otherwise light hazard class building, as may occur in office and residential type buildings, the minimum capacity required by Table 16 for a stored water source may, when used as one supply of a duplicate supply system only, be halved, provided that the maximum period of inflow for a suction tank relying on automatic inflow is halved, i.e. to 30 min.

Table 16 – Water storage capacity for ordinary hazard class systems

Occupancy group	Maximum height of sprinklers in building or stage above lowest sprinkler	Minimum ^a capacity
	m	L
1	15	55000
	30	70000
	45	80000
	60	90000
	75	100000
2	15	105000
	30	125000
	45	140000
	60	160000
	75	175000
3	15	135 000
	30	160000
	45	185000
	60	205 000
	75	220 000
3 Special	15	160000
	30	185000
	45	205000
	60	225 000
	75	245 000

^a Where the system is divided into various pressure stages as required by 5.6, the tank capacity may be based on the maximum stage height rather than on the total height of the building. For storeyed buildings in excess of 15 m in height with different hazard classes at various levels, economies may be effected by calculating the minimum capacities of storage tanks, provided that in the calculations of distribution pipework no advantage has been taken of the difference in static pressure as allowed in 11.4.2.3. The minimum capacity must be sufficient to supply the pump for 1 h when running at its nominal rating.

The nominal rating of the pump is that point on its characteristic curve which satisfies the formula:

$$Q = K\sqrt{(P - h)}$$

where

Q = rate of flow, in litres per minute;

K = constant as set out in the following table;

P = pressure at pump discharge, in kilopascals;

h = pressure equivalent of the height above the pump of the sprinkler array hydraulically nearest the valves, in kilopascals.

Values of constant K

Hazard class	K
Light hazard	50
Ordinary hazard:	
Group 1	83
Group 2	145
Group 3	190
Group 3 special	195
High hazard ^b	Determined by hydraulic calculation of the hydraulically most favourable area of operation

^b For high hazard systems designed in accordance with Tables 25(A) to 25(C), the requirements of the formula may be ignored, in which case the maximum flow rate of the pump is taken as 150 percent of the flow rate given in column 2 of Table 22 for the appropriate design density of discharge.

The storage capacity shall be not less than that allowed in Table 16 for a building of 15 m for the particular occupancy group. In fully hydraulically calculated ordinary hazard systems, the water requirement is the maximum calculated demand in litres per minute for the hydraulically most favourable area for a period of 60 minutes (see clause 13).

11.2.2.2 Pump suction tanks

Pump suction tanks shall have an effective capacity reserved entirely for the sprinkler system not less than that specified in Table 17 except that, where there is an automatic inflow which can be relied upon at all times, a smaller capacity will be allowed, provided that the pump can operate at full capacity for not less than 1 hour, subject to the following minimum capacities (see also 5.8.1):

Group 1	–	25 m ³
Group 2	–	25 50 m ³
Group 3	–	75 m ³
Group 3 Special	–	100 m ³

NOTE – Sharing of the storage tanks for sprinkler system and domestic purposes is not allowed. The pipes for the sprinkler system shall not be connected to any pipes or storage tanks conveying potable water.

11.2.3 Pumps

11.2.3.1 General

Pumps shall comply with the appropriate requirements of 5.10 and 5.11. (see also 5.6).

11.2.3.2 Pumps drawing from pump suction tanks

The performance characteristics of pumps drawing from pump suction tanks shall comply with Table 17.

**Table 17 – Performance characteristics for automatic pumps
drawing from pump suction tanks**

1	2	3	4	5	6
Occupancy group	Sprinkler height ^a m	Nominal rating ^b		Minimum characteristics	
		Pressure kPa	Flow L/min	Pressure kPa ^c	Flow L/min
1	15	120	900	220	540
				250	375
	30	190	1150	370	540
				400	375
	45	260	1340	520	540
				550	375
	60	330	1500	670	540
2				700	375
	75	400	1650	820	540
				850	375
	15	130	1700	250	1000
				290	725
	30	200	2050	400	1000
				440	725
3	45	260	2350	550	1000
				590	725
	60	320	2650	700	1000
				740	725
	75	380	2900	850	1000
				890	725
	15	140	2250	290	1350
3 Special				320	1100
	30	200	2700	440	1350
				470	1100
	45	250	3100	590	1350
				620	1100
	60	320	3400	740	1350
				770	1100
3 Special	75	380	3700	890	1350
				920	1100
	15	190	2650	300	2100
				350	1800
	30	240	3050	450	2100
				500	1800
	45	310	3400	600	2100
3 Special				650	1800
	60	370	3750	750	2100
				800	1800
	75	430	4050	900	2100
				950	1800

^a Height of highest sprinkler above pump.
^b Pump (including any orifice plates) must comply with the nominal rating within limit of ± 5 percent on flow at the stated pressure.
^c Plus friction loss between pump and control valves.

11.2.3.3 Pumps drawing from elevated private reservoir

The maximum flow rate of the pump shall be taken as the flow rate that is necessary for the combined output of the elevated tank and pump to satisfy the following formulae:

$$Q = K \sqrt{(P - h)}$$

where:

Q = rate of flow in litres per minute;

K = constant as set out in following table for the appropriate hazard class;

P = pressure at pump discharge in kilopascals;

h = pressure equivalent of the height above the pump of the hydraulically most favourable area of operation in kilopascals.

Values of constant K

Hazard class	K
Ordinary hazard:	
Group 1	83
Group 2	145
Group 3	190
Group 3 special	195

11.2.3.3⁴ Pump suction pipe

The minimum nominal diameter of pump suction pipe shall be as follows:

Groups 1 and 2	–	150 mm
Groups 3 and 3 Special	–	200 mm

11.2.3.5 Capacity of fuel tank

The capacity of the fuel tank, which shall be kept full, for a compression-ignition engine driven pump shall be sufficient to allow the engine to run on full load for 4 hours. (see 5.11.3.3(f)(2)). In addition there shall be kept on hand sufficient fuel to run the engine for a further 6 hours.

11.2.4 Proving of water supplies

Water supplies shall be proved in accordance with the requirements of 5.12.

11.3 Spacing of sprinklers

11.3.1 Maximum area coverage per sprinkler

The maximum area coverage per sprinkler shall be as follows:

- | | | | |
|----|---------------------|---|---------------------------------|
| a) | Sidewall sprinklers | – | 9 m ² (see also 6.5) |
| b) | Other sprinklers | – | 12 m ² |

In cold storage warehouse using the air circulation method of refrigeration, provender and rice mills (other than those using the pneumatic system of conveying), film and television production studios, theatres and music halls (stage protection), the maximum area coverage is limited to 9 m² and the maximum distance between sprinklers to 3 m.

11.3.2 Maximum distance between sprinklers on range pipes and between adjacent rows of sprinklers

The maximum distance between sprinklers on range pipes and between adjacent rows shall be as follows:

- | | | | |
|----|-------------------------------------|---|----------------------|
| a) | Sidewall sprinklers along the walls | – | 3.7 m (see also 6.5) |
| b) | Other sprinklers: | | |
| | Standard spacing (see 6.1) | – | 4.2 m |
| | Staggered spacing (see 6.2): | | |
| | Between sprinklers | – | 4.6 m |
| | Between rows | – | 4.2 m |

NOTE – See also 11.3.1 for reduced distances for certain occupancies.

11.3.3 Maximum distance from walls and partitions (see also 6.4.2 and 6.5)

The maximum distance of sprinklers from walls and partitions shall be as follows:

- | | | | |
|----|------------------------------------|---|---|
| a) | Sidewall sprinklers from end walls | – | 1.8 m |
| b) | Other sprinklers | – | 2.1 m or half the design spacing
whichever is the lesser |

11.4 System components

11.4.1 Sprinklers

11.4.1.1 Size and type

Sprinklers shall have a nominal orifice size of 15 mm and may be conventional, pendent spray, upright spray, sidewall, flush, recessed or concealed.

11.4.1.2 Special sprinklers

Notwithstanding the requirements of 11.4.1.1, other types of sprinklers may be incorporated in the system. Such systems shall be classified as special system and shall conform to the additional requirements of 3.4.3.

11.4.2 Piping

11.4.2.1 General

Pipe sizes shall be determined either by full hydraulic calculation, or partially by pre-calculated pipe sizing tables and partially by hydraulic calculation.

Figure 3 illustrates piping arrangements showing the various design points from which the piping shall be calculated hydraulically. Piping at the extremities of systems downstream of each design point (16/18-sprinkler point) shall comply with the requirements of Table 18.

11.4.2.2 Pre-calculated piping

Where ranges are directly connected to the distribution pipe without risers (or drops) as defined in 2.36, the design point shall be taken as the last elbow, tee or branch downstream of which the 16/18-sprinkler array is located (design points A and B in Figure 3).

Where ranges are connected to the distribution pipe with risers (or drops), such risers (or drops) shall be considered as distribution pipes, and the design point shall be moved downstream to the point of connection of the riser (or drop) nearest the installation valves in the 16/18-sprinkler array (design points C, D and E in Figure 3).

Where the number of sprinklers in a separate array (see 2.37) is less than the number of sprinklers for which the distribution pipes are hydraulically designed, the design point shall be taken as the point of connection of the range nearest the installation valves in such separate array (design point F in Figure 3).

Table 18 – Maximum number of sprinklers on pre-calculated piping

(a) Range pipes

Ranges	Nominal internal pipe size mm	Maximum number of sprinklers permitted on range pipes ^a
Ranges at remote end of all distribution pipes:		
(i) Two and-side layouts: Last two ranges	25 32	1 2
(ii) Three end-side layouts: Last three ranges	25 32	2 3
(iii) All other layouts: Last range	25 32 40 50	2 3 4 9
All other ranges	25 32 40 50	3 4 6 9
^a The number of sprinklers on a range pipe when the ranges run longitudinally under roofs sloping at an angle in excess of 6 degrees must not exceed 6. The maximum length of 25 mm pipe allowed in any route from a sprinkler to the installation valves is 15 m including allowance for elbows.		

(b) Distribution pipes

Distribution pipes	Nominal internal pipe size mm	Maximum number of sprinklers to be fed by distribution pipe
Pipes at extremities of system:		
(i) Two and-site layouts	32 40 50 65	2 4 8 16 ^b
(ii) All other layouts	32 40 50 65	3 6 9 18 ^b
Pipes between the above-mentioned extremities and the installation valves	To be individually hydraulically calculated in accordance with 11.4.2.3	
^b This requirement does not preclude the use of 65 mm diameter pipe between the design point and the installation valves if hydraulic calculation shows that this is possible.		

Where single sprinklers are connected to horizontal pipes by risers (or drops), such risers shall be considered range pipes. Where such risers (or drops) exceed 300 mm in length, the horizontal pipes to which they are connected shall be sized as distribution pipes to a maximum of 18 sprinklers.

For complex piping arrangements requiring the use of both arm pieces and risers (or drops), piping feeding such arrangements shall be sized as a combination of range and distribution pipes in accordance with Table 18 to a maximum of 18 sprinklers.

NOTE – Annex B provides a series of sketches illustrating these requirements

11.4.2.3 Hydraulic calculation of piping (partly pre-calculated system)

The size or sizes of the piping (including main distribution pipes and all risers) between each design point and the installation valves shall be calculated on the basis that with a rate of flow of 1800 L/min the aggregate pressure loss due to friction does not exceed 150 kPa. The losses given in Table 19 (A) shall be used for these calculations.

Table 19 (A) – Pressure losses for medium ^a tubes to SS 17

Nominal internal pipe size mm	Loss of pressure per metre length of pipe with a flow of 1800 L/min ^b kPa
65	10.3
80	4.7
100	1.3
150	0.19
200	0.046

^a 1800L/min from the data in clause 13. The loss of pressure at each elbow bend or tee where the water is turned through an angle should be taken as equivalent to that incurred through 3 m of straight pipe.

^b Where the number of sprinklers in a separate array is less than the number for which the distribution pipes are hydraulically calculated, up to a maximum of 12 sprinklers, the losses may be calculated on the arbitrary basis of 70 L/min per sprinkler (see Table 19(B)) from the design point of such separate array back to the junction with another distribution pipe, then at the full flow rate of 1800 L/min. Aggregate loss to the valves is not to exceed 150 kPa. An example of this is illustrated in Figure 3 between design point F, point Y and control valves. Calculations for the ringed portions of distribution pipes shall be based on these pressure losses on the total length of each pipe size multiplied by a factor of 0.14.

Table 19 (B) – Pressure losses for medium ^c tubes to SS 17 – Ordinary hazard

Number of sprinklers in array	Loss of pressure per metre length of pipe, kPa							
	Nominal internal pipe size, mm							
	25	32	40	50	65	80	100	150
1	2.26	0.59	0.28	0.08	0.02			
2	8.15	2.12	1.01	0.32	0.09	0.04		
3		4.48	2.14	0.67	0.19	0.09		
4		7.64	3.65	1.15	0.32	0.15		
5			5.51	1.74	0.49	0.22	0.06	
6			7.73	2.44	0.68	0.31	0.08	
7				3.24	0.91	0.41	0.12	
8				4.15	1.16	0.53	0.14	
9				5.16	1.45	0.66	0.18	
10					1.76	0.80	0.22	0.03
11					2.10	0.6	0.27	0.04
12					2.47	1.13	0.31	0.05

^c The loss of pressure at each elbow bend or tee where the water is turned through an angle should be taken as equivalent to that incurred through 3 m of straight pipe.

Pipes may only reduce in diameter in the direction of flow of water to any sprinkler.

Where sprinkler protection is provided at various height levels, pressure loss to the design point at each level may be increased by an amount equal to the difference in static pressure between the level of the sprinklers on the floor concerned and the level of the highest sprinklers on the site. This may apply in storeyed buildings, buildings having more than one main height level of protection within a storey (eg. mezzanine floor or extensive platform levels), or separate buildings of different height on the same site, provided that each installation so designed shares a common water supply with the installation having the highest sprinklers on the site, and has a water supply running pressure (see 11.2) based on the highest sprinklers on the site measured on each installation gauge.

Where a system is divided into pressure stages as required by 5.6, no advantage may be taken of the difference in height of sprinklers in another stage.

In all cases where advantage is taken of this static pressure gain, the height in metres of the highest sprinkler above the installation gauge used for the calculation for the particular installation shall be indicated on the fire protection plan with reference to that installation.

The fire protection plan shall also state the necessary pressure requirements at the installation gauge for the proving tests based on the highest sprinkler. The height of the highest sprinkler used for these calculations shall be that of a sprinkler actually installed or intended to be installed at the time of specifying the design of a particular installation distribution piping system.

11.4.2.4 Fully hydraulically calculated systems

Where complex piping configuration is involved and/ or where economics in design can be affected, the piping may be designed on the basis of individual hydraulic calculation of pipes throughout the system. Where full hydraulic calculation is used, it shall be specifically approved by the relevant authority, and shall meet the requirements set out in clause 13.

11.4.2.4 Sprinklers in concealed spaces

Where sprinkler protection is required under 6.6.1 and 6.6.2, such protection shall be installed with either 10 mm or 15 mm nominal size sprinklers, but with ordinary hazard spacing and pipe sizing. Where the concealed spaces contain nothing but water pipes, electric wiring or air conditioning trunking of non-combustible material, the sprinkler protection may be installed on the light hazard spacing basis i.e. with 10 mm nominal size sprinklers and maximum area coverage of 21 m² per sprinkler, but with piping as for ordinary hazard systems.

Where sprinkler protection is installed on the extended (skeleton) spacing basis under 6.6.2.3, such protection shall be installed with 10 mm nominal size sprinklers, but with piping as for ordinary hazard systems.

Sprinklers may be fed individually from piping feeding sprinklers in the room below, provided that in the determination of the size of range and distribution pipes up to the design point the sprinklers above and below are taken cumulatively.

11.5 System drainage

All pipes shall be arranged with adequate slope for drainage as specified in 8.11.

NOTE – Piping in all systems, including piping in wet pipe systems, should be arranged to drain to the installation drain valve which should be not less than 50 mm diameter.

12 High hazard class systems

12.1 Design data

12.1.1 General

High hazard systems shall be hydraulically designed to provide an appropriate density of discharge over an assumed area of operation (number of sprinklers likely to operate) in all areas including the hydraulically most unfavourable areas of the protected building.

The design densities of discharge and the assumed areas of operation shall be as follows:

- a) Process risks (see also 12.1.2)
 - 1) Design density of discharge – 7.5 mm/min to 12.5 mm/min
 - 2) Assumed area of operation – 260 m²
- b) High piled storage risks (see also 12.1.3)
 - 1) Design density of discharge – 7.5 mm/min to 30 mm/min
 - 2) Assumed area of operation – 260 m² or 300 m²
(according to density of discharge)

12.1.2 Process risks

For process risks, density of discharge and assumed areas of operation shall be as given in Table 20.

12.1.3 High piled storage risks

12.1.3.1 Methods of storage

The methods of storage which may be found in a high piled storage risk are as follows:

- a) Free-standing storage or block stacking;
- b) Bin-box. A container up to 1.8m³, having one vertical face open;
- c) Storage in post or box pallets (where the post or box pallets have solid floors, the storage shall be taken as solid shelf storage);
- d) Storage on solid shelves;
- e) Storage on multiple row and drive-through racks;
- f) Palletised rack storage;
- g) Bonded stores (spirituous liquors) storage.

Table 20 – Discharge density and assumed area of operation for process risks

Occupancy	Design density mm/min	Assumed area of operation m ²
Aircraft engine testing	10.0	260
Aircraft hangars	7.5	Zone protection(deluge system)
Celluloid manufacturers and celluloid goods manufacturers	12.5	260
Distilleries (still houses)	12.0	260
Electrical/ electronic manufacturing and assembly (predominantly plastic components)	7.5	260
Exhibition halls with unusually high ceilings and high concentration of combustibles	12.0	260
Fire lighter manufacturers	10.0	260 (Note 2)
Fireworks manufacturers	10.0	Complete deluge protection required for each building
Flammable liquid spraying	12.0	260
Floor cloth and linoleum manufacturers	7.5	260
Foam plastics goods manufacturers and warehouses	12.0	260
Foam rubber goods manufacturers and warehouses	12.0	260
Paint and varnish works (solvent based)	7.5	260 (Note 2)
Plastics goods manufacturing and process works (where plastic is one of the basic materials in the operation)	12.0	260
Resin, lamp black and turps manufacturers	7.5	260 (Note 2)
Rubber substitute or India rubber substitute Manufacturers	7.5	260 (Note 2)
Tar distillers	10.0	260 (Note 2)
Theatrical scenery store	10.0	260
Woodwool manufacturers	7.5	260
Vehicle repair workshops	10.0	260
NOTE 1 – Assumes use of 141°C rated sprinklers.		
NOTE 2 – Supplementary protection by high or medium velocity sprayers, as appropriate, will be required in these risks in areas where solvents or other flammable liquids are stored or handled (see 6.6).		

12.1.3.2 General design data

The design density of discharge for high piled storage risks depends on the hazardous nature of the stock and the height of storage. These risks are subdivided into four categories according to the severity of the hazard of the stock (see 3.2.4.2).

Tables 21(A) and 21(B) indicate the appropriate density of discharge and assumed area of operation according to the category, method of storage and stack height where roof or ceiling protection only is provided. Where storage fixtures are of solid or shelved construction, the requirements of 6.7.8 shall apply.

Table 21 (A) – Discharge density and assumed area of operation for high piled storage risks involving free-standing storage or block stacking where ceiling or roof protection is provided

Discharge density ^a mm/min	Assumed area of operation m ²	Maximum stack height, m ^b			
		Category 1	Category 2	Category 3	Category 4
7.5	260	5.3	4.1	2.9	1.6
10.0		6.5	5.0	3.5	2.0
12.5		7.6	5.9	4.1	2.3
15.0		-	6.7	4.7	2.7
17.5		-	7.6	5.2	3.0
20.0	300		-	5.7	3.3
22.5				6.3	3.6
25.0				6.7	3.8
27.5				7.2	4.1
30.0				-	4.4

^a Where storage is encapsulated (see 2.13) the ceiling sprinkler discharged density is to be increased by 25% for Category 1 and 50% for Category 2 and no special requirements for Category 3 and 4.

^b It is considered that overall storage heights not exceeding the following in the various categories are suitable for ordinary hazard systems and need not be regarded as 'high piled storage'.

Category of storage	Overall stack height, m	
	Non-encapsulated storage	Encapsulated storage
1	4.0	3.0
2	3.0	2.25
3	2.1	1.6
4	1.2	0.9

NOTE 1 – The term 'storage' includes the warehousing or the temporary depositing of goods or materials while undergoing process.)

NOTE 2 – To provide for any future requirements, the height of storage should be taken as not less than 1 m below any ceiling or roof.

Table 21 (B) – Discharge density and assumed area of operation for high piled storage risks involving post or box pallets (in single or double rows) or palletised rack storage where roof or ceiling protection only is provided

Discharge density ^c mm/min	Assumed area of operation m ²	Maximum stack height, m ^d			
		Category 1	Category 2	Category 3	Category 4
7.5	260	4.7	3.4	2.2	1.6
10.0		5.7	4.2	2.6	2.0
12.5		6.8	5.0	3.2	2.3
15.0		-	5.6	3.7	2.7
17.5			6.0	4.1	3.0
20.0	300			4.4	3.3
25.0				5.3	3.8
30.6				6.0	4.4

^c Where storage is encapsulated (see 2.13) the ceiling sprinkler discharge density is to be increased by 25%.

^d It is considered that overall storage heights not exceeding the following in the various categories are suitable for ordinary hazard systems and need not be regarded as 'high piled storage'.

Category of storage	Overall stack height, m	
	Non-encapsulated storage	Encapsulated storage
1	3.5	2.7
2	2.6	2.0
3	1.7	1.3
4	1.2	0.9

NOTE 1 – To provide for any future requirements the height of storage should be taken as not less than 1 m below any ceiling or roof.

NOTE 2 – Good practice dictates that box or post pallet storage should not exceed 2 rows wide in one direction.

NOTE 3 – Rack storage with aisles less than 1.2 m in width is treated as multiple row racks (see 12.1.3.3).

The maximum storage heights of 7.6 m for category 1 and 2, 7.2 m for category 3, and 4.4 m for category 4 indicated in Table 21(A) are considered to be a limiting factor to efficient sprinkler protection where sprinklers are provided at the ceiling or roof only.

The maximum storage heights of 6.8 m for category 1, 6.0 m for category 2 and 3, and 4.4 m for category 4 indicated in Table 21(B) are considered to be a limiting factor to efficient sprinkler protection where sprinklers are provided at the ceiling or roof only. Where storage in racking and post or box pallets is above these heights intermediate level protection shall be provided.

12.1.3.3 Storage in multiple row and drive-through or flow-through racks

Intermediate sprinklers shall be installed in multiple row and drive-through or flow-through racks where storage heights exceed the ordinary hazard limitations for post pallets and palletised rack storage in note 2 to Table 21(B) in accordance with 12.1.3.4.

NOTE – Rack storage with aisles less than 1.2 m in width shall be treated as multiple row racks.

12.1.3.4 Intermediate level protection in storage racks

12.1.3.4.1 General

Supplementary intermediate level protection shall be provided in storage racks where heights of storage exceed those in Table 21(B).

Flow rates for intermediate level sprinkler protection shall be hydraulically calculated as set out in 12.4.2.4.

Where racking does not exceed 3.2 m in width, one row of sprinklers shall be located centrally along the length of the rack. Where racking exceeds 3.2 m width, but does not exceed 6 m, two rows of sprinklers shall be provided. The design of protection for racking exceeding 6 m in width shall be individually assessed. (See Figures 23 (a), (b) and (c) for maximum spacing, stagger spacing and maximum area coverage per sprinkler.) Whenever any rack or structural steelwork is likely to significantly interfere with water discharge from sprinklers, additional sprinklers shall be provided and taken into account in water flow calculations.

Each intermediate level sprinkler shall be fitted with a metal water shield 80 mm in diameter, located immediately above the sprinkler. For sprinklers mounted upright the shield shall not be attached directly to the sprinkler deflector. Any bracket supporting the shield shall cause minimal obstruction to the water distribution.

Provision shall be made for the protection of piping and sprinklers against mechanical damage (see 7.9 and 8.7).

12.1.3.4.2 Location of intermediate level sprinklers

Sprinklers within racks shall be positioned so that there is not less than 150 mm clearance between the deflectors and the top of the storage in the tier immediately below the line of sprinklers.

Sprinklers shall be located in racks as follows:

- a) Category 1 or 2 goods:
 - 1) Every alternate rack tier, but not exceeding 3.7 m from the floor to the lowest level and between successive levels.
 - 2) Every alternate junction of longitudinal and transverse flues or gaps between pallets.
 - 3) Sprinklers shall be staggered between tiers.
 - 4) The horizontal spacing of sprinklers within tiers shall not exceed 2.8 m (see Figure 23(a)).
- b) Category 3 goods (or category 1 and 2 goods when they are mixed with category 3 goods):
 - 1) Every alternate rack tier, but not exceeding 3.7 m from the floor to the lowest level and between successive levels.
 - 2) Every junction of the longitudinal and transverse flues or gaps between pallets.
 - 3) The horizontal spacing of sprinklers within tiers shall not exceed 1.4 m (see Figure 23(b)).
- c) Category 4 goods (or category 1, 2 and 3 goods when they are mixed with category 4 goods):
 - 1) At every tier, but not exceeding 2.3 m from the floor to the lowest level and between successive levels.
 - 2) Every alternate junction of the longitudinal and transverse flues or gaps between pallets.
 - 3) Sprinklers shall be staggered between tiers.
 - 4) The horizontal spacing of sprinklers within tiers shall not exceed 2.8 m (see Figure 239(c)).

Provided that the roof or ceiling protection is not more than 3 m above the top of the stored goods, the uppermost row of intermediate level sprinklers may be omitted if this would otherwise be located at the top of the stored goods (see Figures 23 (a), (b), (c) and (d)).

12.1.3.4.3 The flow requirements of sprinklers within the racks shall be calculated on the assumption of an operational pressure of 200Kpa at the hydraulically most unfavourable sprinkler when:

- a) three sprinklers are operating at every sprinkler level for category 1, 2 and 3 goods;
- b) two sprinklers are operating at every sprinkler level for category 4 goods;
- c) where rack aisles exceed 2.4 m in width, at least one rack shall be assumed to be involved;
- d) where rack aisles exceed 1.2 m in width and do not exceed 2.4 m, at least two racks shall be assumed to be involved;
- e) where racks are closer than 1.2 m (multiple row racks), at least three racks shall be assumed to be involved; and

- f) in no case, need more than three rows of sprinklers, as seen in plan view, be assumed to be simultaneously involved at each sprinkler level.

12.1.3.4.4 Design data for roof or ceiling sprinklers

Where intermediate level sprinklers are provided:

- a) the density of discharge for the roof or ceiling sprinklers shall be appropriate to the height of storage above the highest level of intermediate level protection which can be taken from Table 21(B) with a minimum density of discharge of 7.5 mm/min; and
- b) the assumed area of operation of roof or ceiling sprinklers shall be taken as, for wet pipe systems, 260 m² irrespective of total stack height.

12.1.3.4.5 The floor area controlled by a single installation of intermediate level sprinklers, shall not exceed 4000m² of floor area occupied by the racks, including aisles.

12.1.3.5 Sprinkler protection of building columns

Where building columns having a fire resistance rating of less than 2 hours is enclosed in racks of high piled storage and the columns, additional sprinklers shall be provided to apply water over the surface area of the column at an application rate of not less than 10 mm/min. Water run-down on the column may be taken into account. In such cases, the run-down shall not exceed 4.5 m and shall be uninterrupted. The discharge from these sprinklers within the assumed area of operation shall be included in water supply calculations.

12.1.3.6 Bonded stores (spirituous liquors) - rack storage

12.1.3.6.1 General

For barrel storage in racks in bonded stores, the provisions for high piled storage risks shall be modified in accordance with 12.1.3.6.2 to 12.1.3.6.4, as appropriate.

12.1.3.6.2 Double rack storage with aisles and walkways (see Figure 24 (a))

The following modifications shall apply to double rack storage with aisles between and having walkways at various levels:

- a) Storage height not exceeding 9.7 m – For storage heights not exceeding 9.7 m, roof or ceiling protection only is acceptable. Table 22 shall be used to obtain densities of discharge and assumed area of operation where storage heights exceed 7.6 m.
- b) Storage height exceeding 9.7 m – For storage heights exceeding 9.7 m, intermediate level protection shall be installed beneath walkways at intervals not exceeding 6.5 m commencing with the lowest walkway. Sprinklers under walkways shall be spaced at not more than 3.5 m and the maximum area coverage per sprinkler at each intermediate level shall not exceed 11 m². Sprinklers at alternate levels shall be staggered in relation to the rows of sprinklers above and below.

The flow requirements of walkway sprinklers shall be calculated with an operational pressure of not less than 200 kPa at the hydraulically most unfavourable sprinkler when seven sprinklers are operating at each walkway level protected.

**Table 22 – Discharge density and assumed area of operation at ceiling
for bonded stores (spirituous liquors) rack storage**

Category of storage	Height of storage	Discharge density required mm/min	Assumed area of operation m ²
1	Not more than 5.3 m	7.5	260
	Above 5.3 m but not more than 6.5 m	10.0	260
	Above 6.5 m but not more than 7.6 m	12.5	260
	Above 7.6 m but not more than 8.7 m	15.0	260
	Above 8.7 m but not more than 9.7 m	17.5	260

12.1.3.6.3 Continuous racking without aisles or walkways (see Figure 24 (b))

The following modifications shall apply to continuous rack storage without aisles or walkways:

- a) Storage height not exceeding 5 m – For storage heights not exceeding 5 m, roof or ceiling protection only is acceptable.
- b) Storage height exceeding 5 m – For storage heights exceeding 5 m, intermediate level protection shall be installed throughout at vertical intervals not exceeding 5 m. There shall be a clear space of not less than 500 mm beneath the deflectors of sprinklers in intermediate level protection. Sprinklers shall be positioned over each of the line of gaps between barrel ends with a maximum spacing down each line of 7 m. The maximum area coverage per sprinkler at each intermediate level shall not exceed 7 m². Sprinklers shall be arranged in stagger formation so that, in alternate lines, they are midway between the sprinklers in the adjacent lines. The following design data shall be used:
 - 1) Design density of discharge for sprinklers at intermediate levels – 10 mm/min.
 - 2) Assumed area of operation at each level of intermediate protection – 70 m²

12.1.3.6.4 Clearance below sprinklers

Clearance below sprinklers at roof or ceiling level may be reduced to 300 mm instead of the 500 mm clearance required by 6.4.8.

12.2 Water supplies

12.2.1 Pressure and flow requirements

The pressure and flow for fully hydraulically calculated systems shall be determined by calculation (see 12.4.2.4). Installation standing pressure shall not be less than 800 KPa.

For systems designed in accordance with Table 25(A) to 25(C) the pressure and flow shall comply with the following requirements:

- a) The water supply shall provide the flow and the corresponding running pressure given in Table 23 at the hydraulically most unfavourably situated design point in the high hazard portion of the premises commensurate with the required density of discharge and the area of operation laid down in 12.1 for the particular occupancy category.
- b) Where the high hazard portion comprises less than 48 sprinklers and the provisions of (d) below do not apply, the required flow and running pressure given in Table 23 shall be provided at the level of the highest sprinklers at the point of entry to the sprinkler array.

Table 23 – Pressure/ Flow requirements for high hazard class systems

Density of discharge	Flow rate	Running pressure at the design point (48-sprinkler point) at the level of the highest sprinklers in the high hazard area, kPa						
		Design spacing of sprinklers, m ²						
		(see 12.3.2)						
Mm/min	L/min	6	7	8	9	10	11	12
1. SYSTEMS HAVING PIPING IN ACCORDANCE WITH TABLE 25 (A) AND 15 mm NOMINAL SPRINKLERS								
7.5	2300	-	-	180	225	280	335	395
10.0	3050	180	240	315	390	480	575	680
12.5	3800	270	365	475	600	730	-	-
15.0	4500	380	520	675	-	-	-	-
2. SYSTEMS HAVING PIPING IN ACCORDANCE WITH TABLE 25 (B) AND 15 mm NOMINAL SPRINKLERS								
7.5	2300	-	-	135	175	215	265	315
10.0	3050	130	180	235	300	375	455	545
12.5	3800	200	275	360	460	570	700	835
15.0	4550	280	385	510	650	-	-	-
3. SYSTEMS HAVING PIPING IN ACCORDANCE WITH TABLE 25 (C) AND 15 mm NOMINAL SPRINKLERS								
7.5	2300	-	-	70	90	110	135	160
10.0	3050	70	95	125	160	195	235	230
12.5	3800	110	150	195	245	305	370	435
15.0	4550	160	215	280	355	435	525	625
17.5	4850	215	290	380	480	590	715	-
20.0	6400	280	380	500	630	775	-	-
22.5	7200	350	480	630	795	-	-	-
25.0	8000	435	590	775	-	-	-	-
27.5	8800	525	715	-	-	-	-	-
30.0	9650	620	-	-	-	-	-	-
4. SYSTEMS HAVING PIPING IN ACCORDANCE WITH TABLE 25 (C) AND 20 mm NOMINAL SPRINKLERS								
7.5	2300	-	-	-	-	-	80	95
10.0	3050	-	-	-	95	115	140	165
12.5	3800	-	90	115	145	180	215	255
15.0	4550	95	125	165	210	255	310	365
17.5	4850	125	170	225	280	345	420	495
20.0	6400	165	225	295	370	460	555	655
22.5	7200	205	285	370	470	575	695	-
25.0	8000	255	350	455	575	710	-	-
27.5	8800	305	420	550	690	-	-	-
30.0	9650	360	495	650	-	-	-	-

- c) Where the design area of operation is fed by more than one distribution pipe, the running pressure at the level of the highest sprinklers at the design point shall be either that given in Table 23 for the required density of discharge, or that determined by hydraulic calculation. The flow rate for each distribution pipe shall be determined on the pro rata basis described in (h) below.

- d) Where the area of the high hazard portion of the risk is less than the area of operation given in Table 20, 21(A) or 21(B), as appropriate, the flow rate shown in Table 23 may be proportionately reduced (see (h) below), but the running pressure at the level of the highest sprinklers at the design point shall be that given in the tables for the required density of discharge.
- e) Where the basic design area of operation for a given density of discharge is increased due to circumstances described under 12.1.2 and 12.1.3, the flow rate shall be proportionately increased (see (h) below) but the pressure at the design point shall be maintained.

NOTE – For example, in an high hazard system with design density of 12.5 mm/min and 15 mm sprinklers, with piping conforming to Table 25(C) and spacing of one per 9 m², if the flow rate was increased by 25 % in accordance with 12.1.3 (i.e. from 3800 L/min to 4750 L/min, the appropriate pressure requirement at the design point would be 245 kPa (see Table 23).

- f) Where the design area of operation is greater than the area of high hazard protection, and this area is adjacent to ordinary hazard protection, the total flow rate shall be calculated on the basis of the rate of flow in the high hazard portion being proportional to its area as above (see (h) below), and the flow in the ordinary hazard portion of the risk being equal to 5 times the balance of the area of operation. The pressure at the level of the highest sprinklers in the high hazard portion of the risk at the design point shall be either that given in the tables for the required density of discharge or that determined by hydraulic calculation.
- g) The flow requirements specified in items 3 and 4 of Table 23 apply only to pipe ranges that are horizontal or at a slope not exceeding 5 degrees to the horizontal. Where the angle of 5 degrees is exceeded, the flow requirements shall be increased by 5 percent for each 5 degrees of slope or part thereof, and there shall be a corresponding percentage decrease in the permitted maximum period of inflow for suction tanks (see 12.2.2).
- h) The increased or decreased flow rates referred to in (c), (d), (e) and (f) above shall be determined on a pro rata basis according to the following formula:

$$Q_2 = Q_1 \times a_2 / a_1$$

where:

Q_2 = flow rate required [or in circumstances described in (c), the flow rate in each pipe];
 Q_1 = flow rate required as given in the tables;
 a_1 = area of operation given in the tables for the discharge density required;
 a_2 = area of operation required (or in circumstances described in (c), the area served by each pipe).

- i) Where sprinklers are installed at intermediate levels in racking, all piping, including roof or ceiling level piping, shall be sized by full hydraulic calculation in accordance with clause 13.

The flow requirements of sprinklers within the racks shall be calculated on the assumption of an operational pressure of 200 kPa at the hydraulically most unfavourable sprinkler when:

- 1) three sprinklers are operating at every sprinkler level for category 1, 2 and 3 goods;
- 2) two sprinklers are operating at every sprinkler level for category 4 goods;
- 3) where rack aisles exceed 2.4 m in width, at least one rack shall be assumed to be involved;
- 4) where rack aisles exceed 1.2 m and do not exceed 2.4 m, at least two racks shall be assumed to be involved;

- 5) where racks are closer than 1.2 m (multiple row racks), at least three racks shall be assumed to be involved; and
- 6) in no case, need more than three rows of sprinklers, as seen in plan view, be assumed simultaneously to be involved at each sprinkler level.

12.2.2 Minimum capacity of water supplies

12.2.2.1 Reservoirs and tanks

The minimum capacities shall be as specified in Table 24. These capacities relate to stored water sources entirely reserved for the sprinkler system (including fire hose reels).

12.2.2.2 Pump suction tanks

The minimum capacities shall be as specified in Table 24. These capacities may be reduced to not less than two-thirds of the listed capacity, provided that reliable automatic inflow is available which will provide sufficient water for the pump to operate at the maximum flow rate for not less than 90 min.

NOTE 1 – Sharing of the storage tanks for sprinkler system and domestic purposes is not allowed. The pipes for the sprinkler system shall not be connected to any pipes or storage tanks conveying potable water.

NOTE 2 – Pressure/ flow tests in connection with the proving of supply should be carried out when the demand for other services is at its peak

Table 24 – Water storage capacity for high hazard class systems

Design density mm/min	Minimum capacity ^a L	Maximum period of inflow for suction tanks min
7.5	237 000	90
10.0	316 000	90
12.5	395 000	90
15.0	474 000	90
17.5	553 000	90
20.0	729 000	90
22.5	820 000	90
25.0	911 000	90
27.5	1002 000	90
30.0	1094 000	90

^a In fully hydraulically calculated systems only, the above capacities may be reduced provided the maximum calculated demand in Litres per minute for the hydraulically most favourable area (see clause 13) for a period of 90 min shows this is to be possible. In no case is it required that the above capacities be increased except that they have to be adjusted where the design is increased or decreased or where supplementary protection is provided in accordance with 12.1.3 and 12.2.

In the case of pump suction tanks, the maximum calculated demand is the maximum flow rate of the pump determined in accordance with 12.1. These capacities must be adjusted where the design area is increased or decreased, or where supplementary protection is provided, in accordance with 12.1.3 and 12.2.1. In fully hydraulically calculated high hazard systems, the water requirement is the maximum calculated demand in litres per minute for the hydraulically most favourable area for a period of 90 min.

12.2.2.3 Supplementary sprinklers

For storage risks coming under the high hazard class where supplementary sprinklers are installed at intermediate levels within racking, the minimum volume of water available shall be sufficient to supply for 90 min the maximum calculated simultaneous flow for both ceiling or roof and intermediate level sprinklers for the hydraulically most favourable area (see also 12.2.1 and 12.4.2.6).

12.2.3 Pumps

12.2.3.1 General

Pumps shall comply with the relevant requirements of 5.10 to 5.11.

12.2.3.2 Pumps drawing from pump suction tanks

The performance characteristics of pumps drawing from pump suction tanks shall comply with the appropriate data in 12.2.3.3.

For systems designed with piping according to Table 25(A) to 25(C), pumps shall be capable of discharging at the excess flow rate of 135 % of the design flow rate (see Table 23 adjusted as required by 12.1 and 12.2 without overloading).

12.2.3.3 Pump suction pipe

The diameter of the pump suction pipe shall be as follows:

Pump suction pipe under positive head conditions - The diameter of the pump suction pipe shall be such that a velocity of 1.8 m/s is not exceeded when the pump is operating at maximum flow rate, i.e. the design flow rate as shown in Table 23 adjusted as required by 12.1 and 12.2 and increased by 135 percent when the installation piping is designed in accordance with Tables 25(A) to 25(C). The above design flow rate shall include the increased flow rate according to the footnote to Table 23, where applicable.

12.2.3.4 Capacity of fuel tank

The capacity of the fuel tank, which shall be kept full, for the compression-ignition engine driven pump shall be sufficient to allow the engine to run on full load for 4 hours (see 5.11.3.3(f)(2)). In addition there shall be kept on hand sufficient fuel to run the engine for a further 6 hours.

12.2.4 Proving of water supplies

Water supplies shall be proved in accordance with the requirements of 5.12.

12.3 Spacing of sprinklers

12.3.1 Maximum distance between sprinklers

Except for sprinklers in storage racks (see 12.1.3.4), the maximum area coverage per sprinkler shall be 9 m².

12.3.2 Maximum distance between sprinklers on range pipes and between adjacent rows of sprinklers

Except for sprinklers in storage racks (see 12.1.3.4), the maximum distance between sprinklers and adjacent rows shall be 3.7 m.

12.3.3 Maximum distance from walls and partitions

The distance of sprinklers from walls or partitions shall not exceed 2 m or half the design spacing whichever is the lesser (see also 6.4.2).

12.4 System components

12.4.1 Sprinklers

12.4.1.1 Size and pattern

Sprinklers shall have a nominal orifice size of 15 mm or 20 mm and may be of conventional or spray pattern type, except that intermediate level sprinklers within storage racks shall have a nominal orifice size of 15 mm and shall be of the conventional type. Where sprinklers are required for building column protection, spray type sprinklers installed horizontally or side wall sprinklers installed vertically shall be used, subject to a minimum orifice size of 10 mm.

12.4.1.2 High temperature sprinklers

In systems, with in-rack sprinklers, protecting high piled storage, 141°C temperature rated sprinklers shall be used at the roof or ceiling, and 68°C to 74°C nominal temperature rated sprinklers shall be installed within storage racks, and for column protection.

12.4.1.3 Special sprinklers

Notwithstanding the requirements of 12.4.1.1 and 12.4.1.2, other types of sprinklers may be incorporated in the system. Such systems shall be classified as special systems and shall conform to the additional requirements of 3.4.3.

12.4.2 Piping

12.4.2.1 General

The appropriate sizing of piping for high hazard systems depends on the following factors:

- a) Required density of discharge.
- b) Spacing of sprinklers.
- c) Size of sprinkler orifice used.
- d) Pressure/ flow characteristics of the water supply.

To accommodate this wide range of conditions, and to provide reasonable economy in piping, systems are designed either partly by the pre-calculated pipe tables and partly by hydraulic calculation (see 12.4.2.2 and 12.4.2.3) or by full hydraulic calculation (see 12.4.2.4).

Figures 25(a) to 25(c) illustrate piping arrangements showing various design points from which the piping shall be calculated hydraulically when the pre-calculated pipe sizing tables are used.

Pipes may reduce in diameter only in the direction of flow of water to any sprinkler. An exception to this requirement may be permitted in systems which are fully hydraulically calculated in accordance with 12.4.2.4.

12.4.2.2 Pre-calculated piping

Where ranges are directly connected to the distribution pipe without risers (or drops) as defined in 2.36, the design point shall be taken as the last elbow, tee or branch downstream of which the 48-sprinkler array is located (see design point A in Figures 25(a) to 25(c)).

Where ranges are connected to the distribution pipe with risers (or drops), such risers (or drops) shall be considered as distribution pipes, and the design point shall be moved downstream to the point of connection of the riser (or drop) nearest the installation valves in the 48-sprinkler array (see design point B in Figures 25(a) to 25(c)).

Table 25(A) – Maximum number of sprinklers on pre-calculated piping for design densities of discharge not exceeding 15 mm/min

Systems with water supplies complying with the pressure/flow requirements for item 1 in Table 23 and using 15 mm (nominal) size sprinklers

(a) Range pipes

Ranges	Nominal internal pipe size mm	Maximum number of sprinklers permitted on range pipes ^a
Ranges at remote end of all distribution pipes:		
(i) Two end-side layouts - Last two ranges	25	1
	32	2
(ii) Three end-side layouts - Last three ranges	25	2
	32	3
(iii) All other layouts - Last range	25	2
	32	3
	40	4
All other ranges	25	3
	32	4

^a No arrangement is allowed with more than four sprinklers per range pipe. No range pipe may be connected to a distribution pipe exceeding 150 mm diameter.

(b) Distribution pipes

Distribution pipes	Nominal internal pipe size mm	Maximum number of sprinklers to be fed by distribution pipe
Pipes at extremities of system	32	2
	40	4
	50	8
	65	12
	80	18
	100	48 ^b
Pipes between the above-mentioned extremities and the installation valves ^c	To be individually calculated hydraulically in accordance with 12.4.2.3	

^b This requirement does not preclude the use of 100 mm pipe between the design point and the installation valves if hydraulic calculation shows that this is possible.

^c The maximum Length of 25 mm pipe allowed in any route from a sprinkler to the installation valves is 15 m including allowance for elbows.

Table 25(B) – Maximum number of sprinklers on pre-calculated piping for design densities of discharge not exceeding 15 mm/min

Systems with water supplies complying with the pressure/flow requirements for item 2 in Table 23 and using 15 mm (nominal) size sprinklers

(a) Range pipes

Ranges	Nominal internal pipe size mm	Maximum number of sprinklers permitted on range pipes ^d
Ranges at remote end of all distribution pipes:		
(i) Two end-side layouts -		
Last two ranges	25	1
	32	2
(ii) Three and-side layouts -		
Last three ranges	25	2
	32	3
(iii) All other layouts -		
Last range	25	2
	32	3
	40	4
All other ranges	25	3
	32	4

^d No arrangement is allowed with more than four sprinklers per range pipe. No range pipe may be connected to a distribution pipe exceeding 150 mm diameter.

(b) Distribution pipes

Distribution pipes	Nominal internal pipe size mm	Maximum number of sprinklers to be fed by distribution pipe
Pipes at extremities of system	50 ^e	4
	65	8
	80	12
	100	16
	150	48 ^f
Pipes between the above-mentioned extremities and the installation valves ^g	To be individually calculated hydraulically in accordance with 12.4.2.3	

^e No distribution pipe less than 65 mm diameter is permitted for four end-side systems.

^f This requirement does not preclude the use of 150 mm pipe between the design point and the installation valves if hydraulic calculation shows that this is possible.

^g The maximum length of 25 mm pipe allowed in any route from a sprinkler to the installation valves is 15 m including allowance for elbows.

Table 25(C) – Maximum number of sprinklers on pre-calculated piping for design densities of discharge up to 30 mm/min

Systems having water supplies complying with the pressure/ flow requirements for item 3 in Table 23 and using 15 mm (nominal) size sprinklers

or

Systems having water supplies complying with the pressure/ flow requirements for item 4 in Table 23 and using 20 mm (nominal) size sprinklers

(a) Range pipes

Ranges	Nominal internal pipe size mm	Maximum number of sprinklers permitted on range pipes^h
End-side arrangements:		
(i) Last three ranges at remote end of all distribution pipes	40	1
	50	3
	65	6
(ii) Other ranges	32	1
	40	2
	50	4
	65	6
End-centre arrangements:		
(i) Two end-centre systems-		
(a) Last three ranges at remote end of all distribution pipes	32	1
	40	2
(b) Other ranges	32	2
(ii) Three and four end-centre systems – All ranges	32	1
	40	2
	50	4

^h No end-side arrangement is allowed with more than six sprinklers per range pipe and no end-centre arrangement with more than four sprinklers per range pipe. No range pipe may be connected to a distribution pipe exceeding 150 mm diameter.

(b) Distribution pipes

Distribution pipes	Nominal internal pipe size mm	Maximum number of sprinklers to be fed by distribution pipe
Pipes at extremities of system	50 ⁱ	4
	65	8
	80	12
	100	16
	150	48 ^j
Pipes between the above-mentioned extremities and the installation valves	To be individually calculated hydraulically in accordance with 12.4.2.3	

NOTE – Annex B provides a series of sketches illustrating these requirements.

ⁱ No distribution pipe less than 65 mm in diameter is permitted for four end-side systems.

^j This requirement does not preclude the use of 150 mm pipe between the design point and the installation valves if hydraulic calculation shows that this is possible.

Where the number of sprinklers in a separate array (see 2.37) is less than the number of sprinklers for which the distribution pipes are hydraulically designed, the design point shall be taken as the point of connection of the range nearest the installation valves in such separate array.

Where single sprinklers are connected to horizontal pipes by risers (or drops), such risers shall be considered range pipes. Where such risers (or drops) exceed 300 mm in length, the horizontal pipes to which they are connected shall be sized as distribution pipes.

For complex piping arrangements requiring the use of both arm-pieces and risers (or drops), piping feeding such arrangements shall be sized as a combination of range and distribution pipes in accordance with Table 25(A) to 25(C).

12.4.2.3 Hydraulic calculation of distribution piping (partly pre-calculated systems)

The distribution and rise pipe from the installation valves to the various nominal terminal points of the network, i.e. at each design point or at the point of entry to each sprinkler array wherever fewer than 48 sprinklers are involved (see 12.2), shall be calculated hydraulically on the basis that, under the relevant flow conditions stated in Table 23, the pressure drop in this individually calculated piping will not exceed the residual pressure available from the water supply when allowance has been made for the pressure required at the design point in Table 23 plus the static head loss due to the height of the highest sprinkler in the high hazard network above the installation valves. Where the highest sprinkler of an high hazard portion of the premises is not beyond the design point, such portion requiring the higher static head shall have its own terminating distribution pipe. The pressure loss in the distribution pipe to each section of the high hazard risk shall be adjusted to that required either by suitably sizing the distribution pipes or by fitting an orifice plate in the feed main (see 12.4.2.5) or by a combination of these two methods. The losses given in Table 26 shall be used for these calculations.

Table 26 – Pressure losses for medium ^a tubes to SS 17

Flow rate L/min	Loss of pressure per metre length of pipe, kPa ^b			
	Nominal internal pipe size, mm			
	100	150	200	250
1000	0.44	0.065	0.015	0.005
1500	0.92	0.14	0.032	0.011
2000	1.6	0.24	0.055	0.018
2300	2.0	0.3	0.071	0.023
3050	3.4	0.51	0.12	0.039
3800	5.2	0.77	0.18	0.059
4550	7.2	1.1	0.25	0.082
4850	8.1	1.2	0.28	0.092
6400	13.5	2.0	0.47	0.15
7200	16.8	2.5	0.58	0.19
8000	20.5	3.1	0.71	0.23
8800	24.4	3.6	0.85	0.28
9650	29.0	4.3	1.0	0.33

^a For heavy tubes, the losses are calculated for the appropriate flow rate from the data in clause 13. The loss of pressure at each elbow, bend or tee where the water is turned through an angle, is to be taken as equal to that incurred through 3 m of straight pipe.

^b Calculations for the ringed portions of distribution pipes shall be based on these pressure losses on the total length of each pipe size multiplied by a factor of 0.14.

12.4.2.4 Fully hydraulically calculated systems

Where complex piping configuration is involved and/ or where economies in design can be effected, the piping may be designed on the basis of individual hydraulic calculation of pipes throughout the system. A typical method of calculation is described in clause 13. An acceptable method of submitting this information is shown in clause 13.

12.4.2.5 Hydraulic balancing of systems with orifice plates

Where it is considered necessary to fit orifice plates in order to assist in hydraulically balancing a system or to meet pump characteristic curves, the diameter of the orifice shall be not less than 50 % of the diameter of the pipe into which the plate is to be fitted. Such orifice plates shall be fitted only in pipes of 50 mm diameter or larger. Orifice plates shall comply with the requirements of Annex A. The relationship between the size of the orifice, the flow and the pressure loss, shall be calculated on the basis of the information given in Annex A.

12.4.2.6 Piping for supplementary protection within storage racking

Where supplementary sprinklers are installed at intermediate levels within storage racking, the piping shall be fully hydraulically calculated. In the sizing of the distribution piping, the water flow required by the intermediate sprinklers shall be added to that required by the roof sprinklers.

Intermediate level protection within storage racks shall be controlled by a separate set of control valves (see also 12.1.3.4), not more than 50 intermediate level sprinklers may be fed directly from roof or ceiling system distribution piping.

Where storage racks are free standing, i.e. not attached to the building structure, and the intermediate sprinklers are fed by pipes connected to the roof piping, the rack piping shall be connected to the distribution pipes by universal joints, or flexible metallic pipes.

12.4.2.7 Sprinklers in concealed spaces

Where sprinkler protection is required under 6.6.1.2, 6.6.1.3, 6.6.2.3 and 6.6.2.4, such protection shall be installed with either 10 mm or 15 mm nominal size sprinklers, but with ordinary hazard spacing and pipe sizing. Where the concealed spaces contain nothing but water pipes, electric wiring or air-conditioning ducting of non-combustible material, the sprinkler protection may be installed on the light hazard spacing basis, i.e. 10 mm nominal size sprinklers with maximum area coverage of 21 m² per sprinkler, but with piping as for ordinary hazard systems.

Where sprinkler protection is installed on the extended (skeleton) spacing basis under 6.6.2.3 and 6.6.2.4, such protection shall be installed with 10 mm nominal size sprinklers but with piping as for ordinary hazard systems.

Sprinklers shall be fed by separate piping from that feeding sprinklers in the room below which may be connected to the main distribution pipe anywhere between the installation control valves and the design point of the most distant array, or, for fully hydraulically calculated systems, the point of entry of the main distribution pipe into the hydraulically most unfavorable area of operation.

The water requirements of sprinklers within concealed spaces need not be taken into account in the sizing of the distribution piping.

12.5 System drainage

All pipes shall be arranged with adequate slope for drainage in accordance with 8.11.

NOTE – Piping in all systems, including piping in wet pipe systems, should be arranged to drain to the installation drain valve which should be not less than 50 mm diameter.

13 Full hydraulic calculation of sprinkler systems

13.1 General

This section details requirements for the design of sprinkler systems based on the hydraulic calculations of all piping. This method of system design, whereby pipe sizes are selected on the basis of water supply characteristics and pressure losses to achieve minimum densities of discharge, is an alternative method to that described in 11.4.2 and 12.4.2 for pre-calculated systems.

In case of Light Hazard class systems and concealed space protection, the system design methods required by this section shall be varied only as permitted by the requirements of clause 10.

13.2 Design requirements for density of discharge

The calculated density of discharge throughout any assumed area of operation, or the entire protected area, whichever is the smaller, with all sprinklers in the area simultaneously discharging, shall not be less than the design density of discharge specified in 10.1, 11.1 or 12.1, as appropriate.

Where in-rack sprinklers are installed within the area of operation, the calculations shall incorporate the simultaneous flow and pressure requirements for roof or ceiling sprinklers, intermediate level sprinklers and sprinklers protecting building columns (see 12.1.3.4, 12.1.3.5 and 12.4.2.6). The system shall be hydraulically balanced at every junction where flows divide or join, in accordance with 13.11.

For the purpose of this sub-clause, when calculating the roof or ceiling level sprinklers, it shall be sufficient to prove that the total flow from every group of four sprinklers within each area of operation, divided by the area in square metres covered by the four sprinklers, is not less than the required density of discharge, or, where fewer than four sprinklers are in open communication, the flow rate from each sprinkler divided by the area covered by the sprinkler, shall be at least equal to the required density of discharge.

The area covered by each sprinkler shall be defined by the center-lines drawn midway between adjacent sprinklers at right angles to the line joining the sprinklers and by the boundary of the area covered (see Figure 26). All dimensions shall be applied in the horizontal plane.

13.3 Assumed area of operation

The assumed area of operation shall comply with 10.1, 11.1 or 12.1.

13.4 Sprinklers in operation

The number of sprinklers assumed to be in simultaneous operation shall be all sprinklers that fall within the assumed area of operation, including any sprinklers located under obstructions within that area, but excluding sprinklers in concealed spaces. The location of the boundary of the assumed area of operation, as well as its shape and position, shall be established as set out in 13.5 and 13.6.

13.5 Position of assumed area of operation

13.5.1 Hydraulically most unfavourable area of operation

For the purpose of determining the hydraulically most unfavourable position, the assumed area of operation shall be located in turn as follows:

- a) Terminal main system with terminal range pipes – At the hydraulically most unfavourable position on each distribution pipe (see Figures 27 (a) and (b)).
- b) Looped main systems with terminal range pipes – At the hydraulically most unfavourable position on the most remote loop (see Figures 27 (c) and (d)).
- c) Gridded systems – Gridded systems, which come in two types, are as follows:
 - 1) With terminal range pipes – At the most unfavourable position as appropriate in one of the following:
 - i) Between the distribution pipes.
 - ii) Partly between the distribution pipes and partly within the area of the terminal ranges.
 - iii) Wholly within the area of the terminal ranges.

- (2) Without terminal range pipes – At the hydraulically most unfavourable position between the distribution pipes (see Figure 27 (e)).

When flowing, the hydraulically most unfavourable area of operation creates the highest pressure requirement in a system. This condition shall be used to ensure that the minimum sprinkler discharge pressure and required discharge density, as defined in 13.2, are met.

NOTE 1 – Where the most unfavourable position is not readily apparent, calculation of more than one assumed area may be required. The most remote area in terms of distance is not necessarily the hydraulically most unfavourable area. Proof that the most unfavourable area has been established may be required.

NOTE 2 – Where it is obvious that other arrays similar to that under consideration are hydraulically nearer to the water supply, such other arrays may be ignored.

13.5.2 Hydraulically most favourable area of operation

For the purpose of determining the hydraulically most favourable area of operation, the assumed area of operation shall be located as follows:

- a) Terminal main system with terminal range pipes – At the hydraulically most favourable position on each distribution pipe (see Figure 27 (a)).
- b) Looped main system with terminal range pipes – At the hydraulically most favourable position on the looped main (see Figure 27 (c)).
- c) Gridded systems – Gridded systems, which come in two types, are as follows:
 - 1) System without terminal range pipes – Adjacent to the hydraulically most favourable distribution pipe (see Figure 27 (e)).
 - 2) System with terminal range pipes – Where the terminal ranges are fed from the most hydraulically favourable distribution pipe, the range pipes shall be either wholly or partially included in the assumed area of operation.

The hydraulically most favourable area of operation, when extrapolated onto the water supply pressure and flow characteristic curve, creates the maximum flow condition in a system. This flow shall be used to determine the water supply requirements.

NOTE – Where the most favourable position is not readily apparent, calculation of more than one assumed area may be required.

13.6 Shape of assumed area of operation

13.6.1 Hydraulically most unfavourable area of operation

The shape of the hydraulically most unfavourable assumed area of operation shall be as near as possible, rectangular, with a dimension parallel to the ranges at least 1.2 times the square root of the required area of operation. Where range pipes run parallel with the ridge of a roof having a slope greater than 68, or along bays formed by full height walls, smoke curtains or beams more than 1m deep, or a combination thereof, with the bays so formed, regardless of intermediate beams, being not more than 9 m wide, the dimension parallel to the ranges shall be at least twice the square root of the required area of operation.

The assumed area of operation shall, where necessary, include sprinklers on both sides of a distribution pipe.

Where the area of the building under consideration is separated from the remainder of the building and is less than the required assumed area of operation specified in 4.2.2 and is less than the required assumed area of operation specified in 13.3, the assumed area of operation shall be the entire sprinkler-protected area.

Where the ranges have an insufficient number of sprinklers to fulfill the 1.2 times or twice the square root of the area requirement, the design area shall be extended to include sprinklers on adjacent ranges supplied by the same distribution pipe, except that where the assumed area of operation is the entire sprinkler-protected area as described above, all sprinklers in the area shall be assumed to be in simultaneous operation, regardless of the number of distribution pipes supplying them.

In determining the number of sprinklers within the assumed area of operation, fractions of sprinklers shall be counted as one sprinkler.

All dimensions shall be applied in the horizontal plane. In all cases, sprinklers making up the area of operation that falls outside the rectangular area shall be placed so as to maximize the hydraulic flow demand of the system, and each total area of operation shall be positioned so as to maximise the hydraulic pressure demand of the system.

Variation in sprinkler spacing, layout, elevation, range centers, sprinkler orifice sizes and pipe sizes, as well as all possible locations, shall be considered when determining the hydraulically most unfavourable location of the assumed area of operation.

13.6.2 Hydraulically most favourable area of operation

13.6.2.1 Terminal main system with terminal range pipes or looped main systems with terminal range pipes.

In a system with terminal mains or looped mains, the shape of the assumed most favourable area of operation shall be, as near as possible, square. As far as is practicable, the sprinklers under consideration shall be served by one distribution pipe only.

The sprinklers assumed to be operating shall be located on each range pipe or pair of range pipes for end-centre arrays, at the hydraulically most favourable position.

Any remaining sprinklers not constituting a full range pipe or pair of range pipes shall be grouped adjacent to the distribution pipe on the next range pipe row of the area so as to maximise the hydraulic flow demand of the system. All dimensions shall be applied in the horizontal plane (see Figures 27 (a), (b), (c) and (d)).

13.6.2.2 Gridded system

In a gridded system, the shape of the most favourable area of operation shall be as near as possible, square.

The sprinklers calculated to be operating shall be located on each range pipe at the hydraulically most favourable position.

Any remaining sprinklers shall be grouped on the next range pipe row of the area so as to maximise the hydraulic flow demand of the system. All dimensions shall be applied in the horizontal plane (see Figure 27 (e) and (f)).

13.7 Water supplies

Water supplies shall comply with the requirements of clause 5. For specific sources of supply, the requirements of 13.8 to 13.9 shall take precedence where systems are fully hydraulically calculated except as varied by 10.1 for Light Hazard class systems.

13.8 Pumpsets

13.8.1 General

Pumpsets shall be capable of satisfying the flow and pressure requirements of any assumed area of operation.

13.8.2 Maximum flow rates

13.8.2.1 Calculation requirements

System maximum flow rates are required for the calculation of pump suction velocities and to establish minimum pump suction tank capacities (see 5.8) and shall be determined in accordance with 13.8.2.2 to 13.8.2.5 below, as applicable:

13.8.2.2 Pumps drawing from pump suction tanks

The maximum flow rate (Q_{max}) shall be assumed to occur at the point of intersection of the pressure-flow characteristics for the hydraulically most favourable area of operation and the pump performance pressure flow characteristics, when the pump suction tank water level is at the normal water line. (see Figure 8)

13.8.2.3 Light hazard systems

The maximum flow rate shall be taken as 1.3 times the required flow rate calculated in accordance with 10.1.

13.8.2.4 Partly pre-calculated high hazard systems

For systems designed in accordance with Table 25(A) to (C), the maximum flow rate of the pump shall be 150% of the flow rate given in Column 2 of Table 23 for the appropriate design density discharge.

13.8.2.5 Partly pre-calculated ordinary hazard systems

For systems designed in accordance with Table 18, the maximum flow rate of the pump shall be taken as the flow rate that is necessary for the combined output of pump and town main to satisfy the following equation:

$$Q = K \sqrt{(P-h)}$$

where:

Q = rate of flow, in litres per minute

P = pressure at pump discharge, in kilopascals, with the town main at maximum pressure

h = pressure equivalent of the height above the pump of the hydraulically most favourable area of operation, in kilopascals

K = constant applicable to the appropriate hazard class as follows: OH 1: 83, OH 2: 145, OH 3: 190, OH Special: 195

13.9 Calculation of pressure loss in pipes

Pressure losses due to water flow through pipes shall be calculated using the Hazen-Williams equation, as follows:

$$P = \frac{6.05 \times Q^{1.85} \times 10^7}{C^{1.85} \times d^{4.87}}$$

where:

- P = loss of pressure per metre of pipe, in kilopascals;
 Q = flow rate of water through pipe, in litres per minute;
 C = roughness coefficient for the type of pipe (see Table 27);
 d = mean internal diameter of pipe, millimetres (see Table 28 and 29).

Table 27 – Design roughness coefficients

Types of pipe	Suggested values
Cast iron (unlined)	100
Steel (galvanised)	120
Steel (black: welded or seamless)	120
Asbestos cement	140
Concrete (bitumen lined)	140
Steel (bitumen lined)	140
Iron or steel (cement lined)	140
Copper	150
Polyethylene	150
PVC (UPVC) unplasticised	150

Table 28 – Mean internal diameters and values of K for steel tube to AS 1074

Nominal dia. (DN) mm	Medium		Heavy	
	Mean (internal) diameter mm	K	Mean (internal) diameter mm	K
20	21.6	2.73×10^{-3}	20.4	3.61×10^{-3}
25	27.3	8.73×10^{-4}	25.7	1.17×10^{-3}
32	36.0	2.27×10^{-4}	34.4	2.83×10^{-4}
40	41.9	1.08×10^{-4}	40.3	1.31×10^{-4}
50	53.0	3.45×10^{-5}	51.3	4.05×10^{-5}
65	68.7	9.76×10^{-6}	67.0	1.10×10^{-5}
80	80.7	4.45×10^{-6}	79.1	4.91×10^{-6}
90 ^a	93.2	2.21×10^{-6}	91.6	2.41×10^{-6}
100	105.1	1.23×10^{-6}	103.3	1.34×10^{-6}
125	129.9	4.38×10^{-7}	128.8	4.58×10^{-7}
150	155.4	1.83×10^{-7}	154.3	1.90×10^{-7}

^a While no longer manufactured, 90 mm the tube is included to facilitate calculations for existing system involving this size.

NOTE – The values for K are based on a roughness coefficient (C) of 120.

Table 29 – Mean internal diameters and values of K for steel tube to AS 1432

Nominal dia. (DN) mm	Type A		Type B	
	Mean (internal) diameter mm	K	Mean (internal) diameter mm	K
20	16.2	7.34×10^{-3}	17.0	5.81×10^{-3}
25	22.1	1.62×10^{-3}	22.9	1.36×10^{-3}
32	28.4	4.77×10^{-4}	29.3	4.10×10^{-4}
40	34.8	1.77×10^{-4}	35.6	1.59×10^{-4}
50	47.5	3.89×10^{-5}	48.3	3.59×10^{-5}
65	60.2	1.23×10^{-5}	61.0	1.15×10^{-5}
80	72.0	5.14×10^{-6}	72.8	4.87×10^{-6}
90	84.7	2.33×10^{-6}	85.5	2.22×10^{-6}
100	97.4	1.18×10^{-6}	98.2	1.13×10^{-6}
125	122.8	3.83×10^{-7}	123.6	3.70×10^{-7}
150	147.0	1.59×10^{-7}	148.2	1.53×10^{-7}

NOTES 1 – These values for K are based on a roughness coefficient (C) of 150.
NOTE 2 – Diameters for pipes in other materials should be obtained from the manufacturers.

Pressure losses in steel, galvanised steel, cast iron, ductile iron and copper pipes may be calculated using a simplified equation as follows:

$$P = KQ^{1.85}$$

where:

- P = loss of pressure per metre of pipe, in kilopascals;
 K = a constant of value given in Table 28 and 29;
 Q = flow rate of water through pipe, in litres per minute.

13.10 Pressure losses

13.10.1 Fittings and valves

Loss of pressure due to water flow through pipe fittings, where the direction of water flow is changed through an angle of 45° or more (other than the change of direction into a sprinkler from an elbow or tee into which the sprinkler is fitted), or through valves, shall be calculated by adding the appropriate equivalent pipe lengths given in Table 30, to the actual lengths in the network under consideration.

13.10.2 Dry pendent (or upright) sprinklers

For a dry pattern sprinkler assembly, the K factor shall be considered to apply at the entry to the sprinkler assembly. Allowance shall be made for the static head gain or loss due to the length and orientation of the dry pipe. No allowance shall be made for friction losses due to flow through the sprinkler assembly dry pipe.

**Table 30 – Equivalent pipe lengths for fittings and valves
(applicable to Hazen-Williams C value of 120 only)**

Fittings and valves	Equivalent length, m													
	Nominal diameter (mm)													
	20	25	32	40	50	65	80	90	100	125	150	200	250	300
90° standard elbow	0.6	0.6	0.9	1.2	1.5	1.8	2.1	2.4	3.0	3.7	4.3	5.5	6.7	8.2
90° long radius elbow	0.3	0.6	0.6	0.6	0.9	1.2	1.5	1.5	1.8	2.4	2.7	4.0	4.9	5.5
45° elbow	0.3	0.3	0.3	0.6	0.6	0.9	0.9	0.9	1.2	1.5	2.1	2.7	3.4	4.0
Tee or cross (flow turned 90°)	0.9	1.5	1.8	2.4	3.0	3.7	4.6	5.2	6.1	7.6	9.1	10.7	15.2	18.3
Gate valve	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6	0.6	0.9	1.2	1.5	1.8
Check valve or alarm valve (swing)	-	1.5	2.1	2.7	3.4	4.3	4.9	5.8	6.7	8.2	9.8	13.7	16.8	19.8
Check valve or alarm valve (mushroom)	-	-	-	-	-	-	-	-	18.0	-	30.0	45.0	60.0	-
Check valve or alarm valve (butterfly)	-	-	-	-	1.8	2.1	3.0	-	3.7	2.7	3.0	3.7	5.8	6.4
NOTE – For other values of C, the equivalent lengths shall be multiplied by factors as follows:														
C Value		100	110	120	130	140	150							
Factor		0.71	0.85	1.00	1.16	1.33	1.51							

13.10 Accuracy of calculations

At every hydraulic junction where flows divide or join:

- the total flow into the junction shall equal the total flow out of the junction to an accuracy of ± 2 L/min; and
- the pressure shall balance to within 0.5kPa.

13.12 Minimum sprinkler discharge pressure

The pressure at any sprinkler, with all sprinklers discharging simultaneously within an assumed area of operation, shall not be less than the following:

- Light hazard system – 70 kPa
- Ordinary hazard system – 35 kPa
- High hazard system – 50 kPa

13.13 Minimum pipe sizes

No distribution or range pipe shall be less than DN 25 except that DN 20 is permitted for connection to single sprinkler in Light Hazard class systems only.

13.14 Velocity limitation

The water velocity shall not exceed 6 m/s at any valve nor exceed 10 m/s at any point in the system, for any stabilised flow condition except that these restrictions shall not apply when calculating the hydraulically most favourable areas of operation.

13.15 Velocity pressure

Velocity pressures may be included in hydraulic calculations at the discretion of the designer. Where included, velocity pressures shall be calculated for both range pipes and distribution mains.

NOTE – The inclusion of velocity pressures in hydraulic calculations improves the predictability of the actual sprinkler system performance.

13.16 Identification of fully hydraulically calculated systems

A durable notice shall be affixed to the riser pipe, immediately adjacent to the control assembly, of any installation that has been hydraulically calculated. The notice shall be similar to that shown in Figure 28 and shall include the following information:

- a) Installation number;
- b) Installation hazard classification(s);
- c) for each hazard class within the installation:
 - 1) the system design requirement at the installation gauge for the most unfavourable and favourable assumed areas of operation;
 - 2) the system design requirement at the pump delivery pressure gauge for the most unfavourable and favourable assumed areas of operation;
 - 3) height of highest sprinklers above the installation gauge in the most unfavourable and unfavourable assumed area of operation; and
 - 4) height difference between installation gauge and pump delivery pressure gauge.

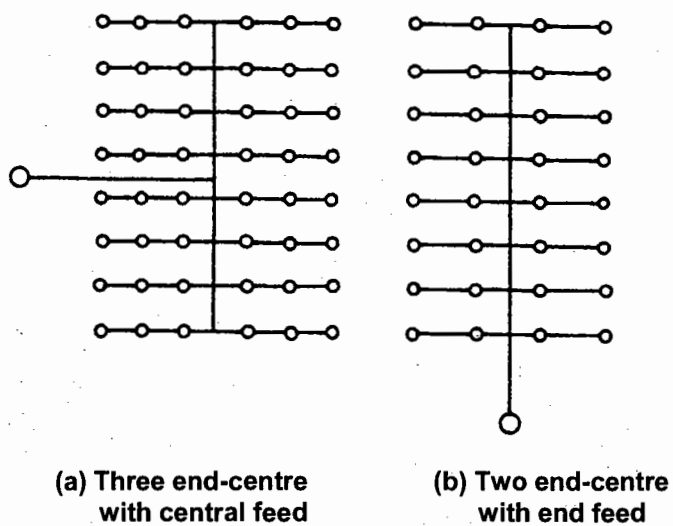


Figure 1 – Typical end-centre arrangements

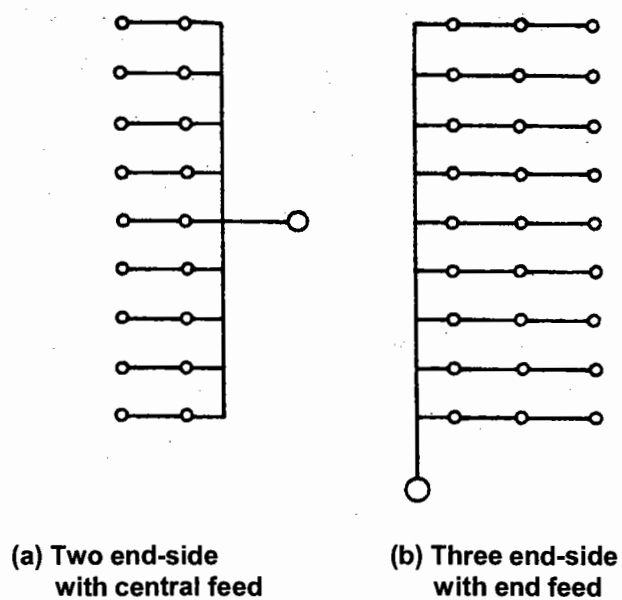
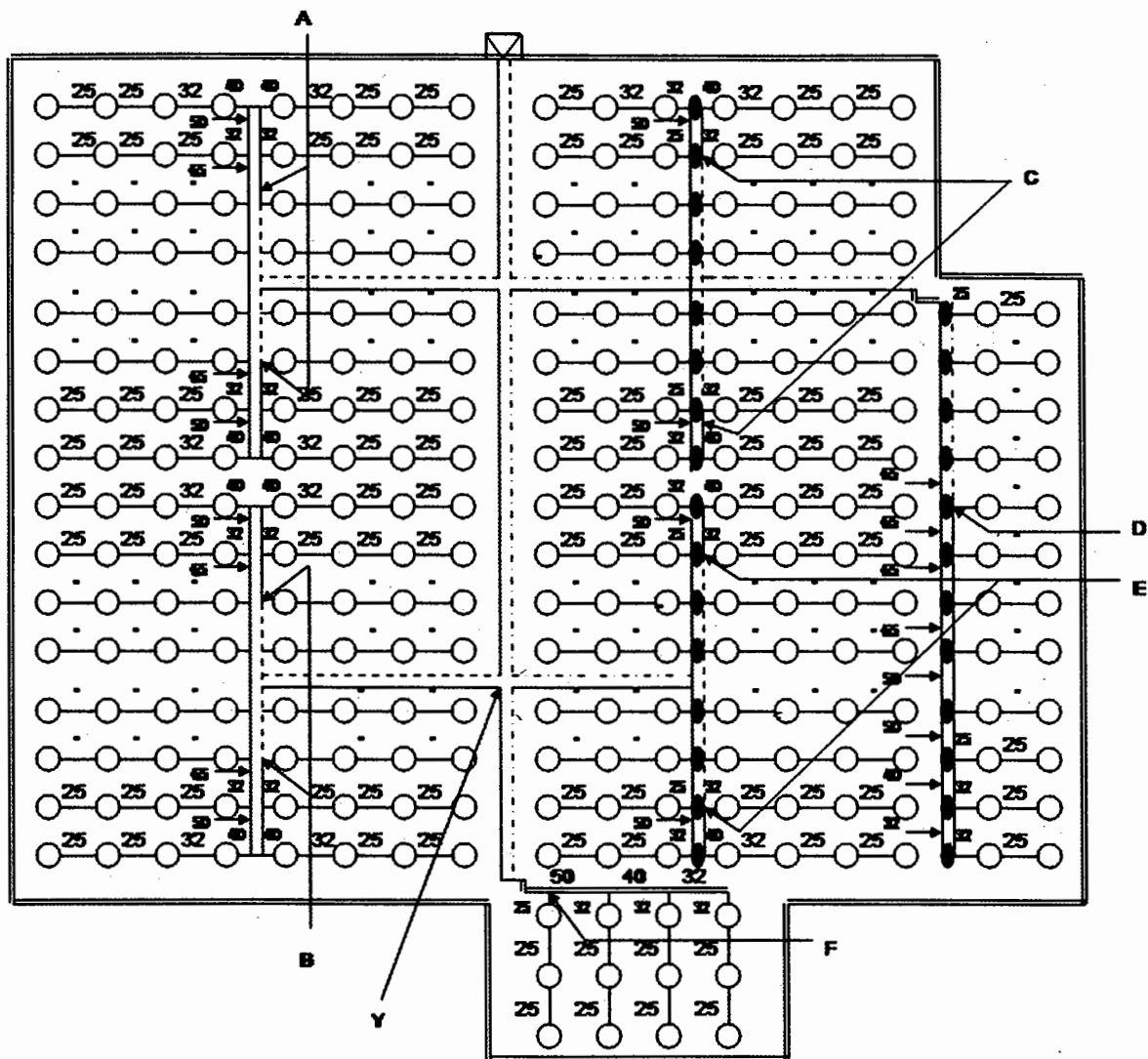

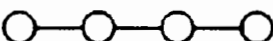


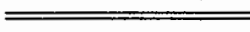
Figure 2 – Typical end-side arrangements




PIPE SIZES (Nominal inside diameter in millimeters)

Riser to range pipe 

Range pipe 

Pre-calculated distribution pipes, i.e. 65 mm diameter and less 

Distribution pipes to be calculated on the basis that with a flow of 1800 L/min the aggregate friction loss shall not exceed 150

kPa between each point A, B, C, D, E, F and the installation valves 

The flow between Y and F shall be taken as 70 L/min per sprinkler (see Table 18B). Between Y and installation valve at 1800 L/min.

SYSTEM COMPRISING 276 SPRINKLERS. Spacing 1:12 m² (3.46 m x 3.46 m). Length of hydraulic route (incl. allowance for bends) between:

Design Points A and installation control valves = 46 m approx.
 Design Points B and installation control valves = 64 m approx.
 Design Points C and installation control valves = 43 m approx.
 Design Points D and installation control valves = 69 m approx.
 Design Points E and installation control valves = 71 m approx.
 Design Points F and installation control valves = 73 m approx.
 Maximum diameter of distribution pipe = 100 mm. Valves = 100 mm.

Figure 3 – Typical ordinary hazard class system

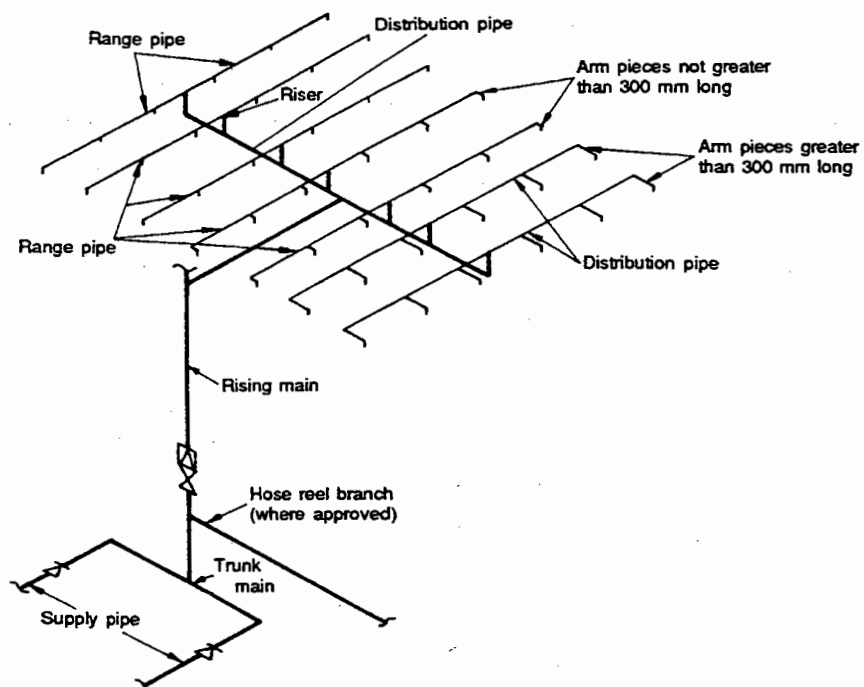


Figure 4 – Piping terms used in Figure 7

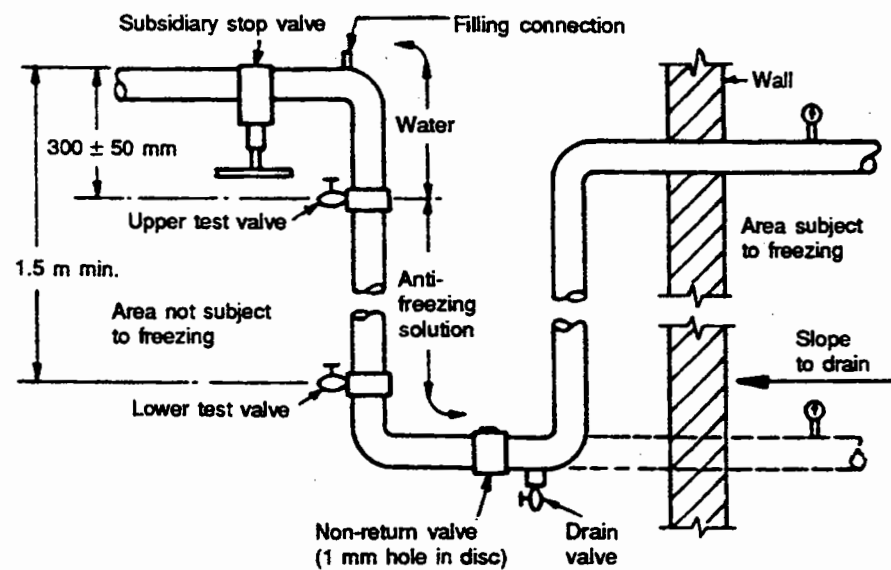


Figure 5 – Arrangement of supply piping and valves, tall-end freezing solution system

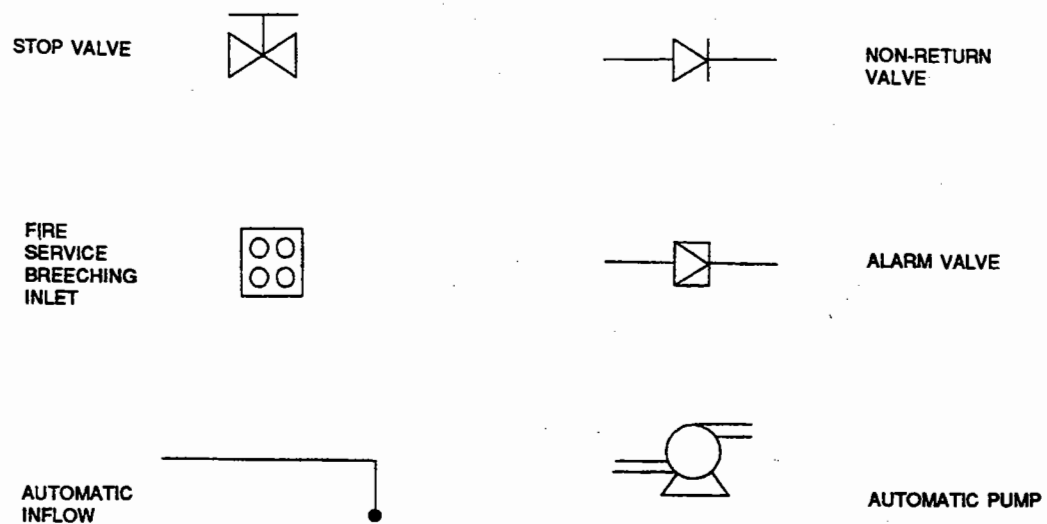
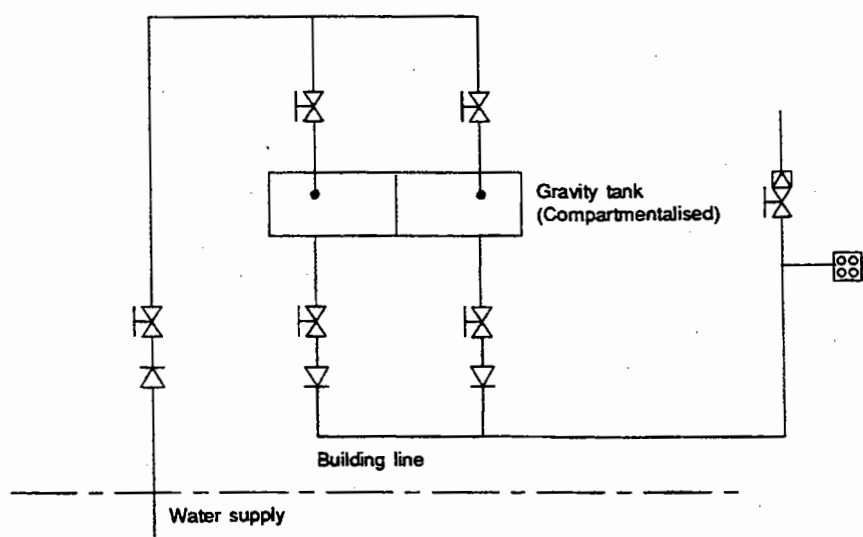
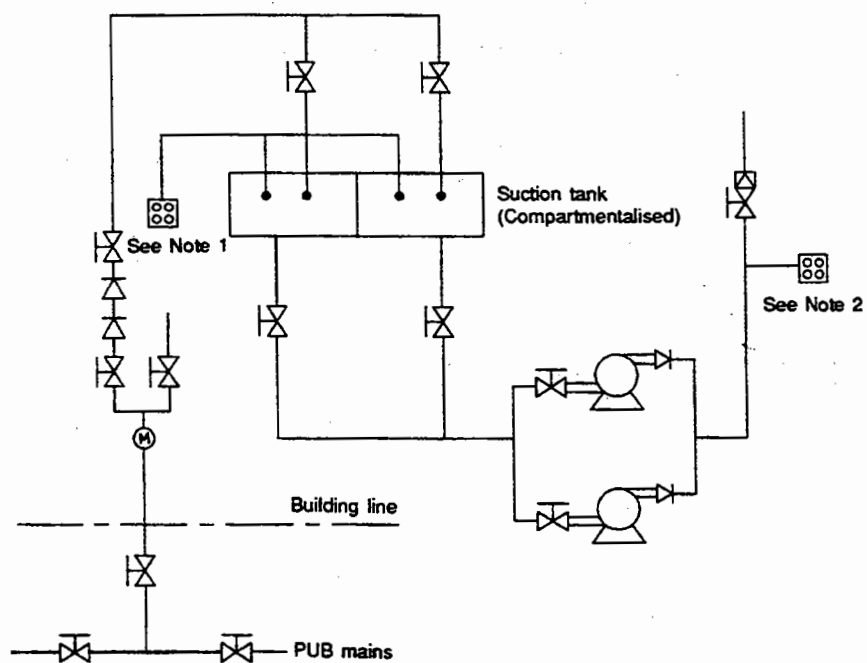


Figure 6 – Symbols used in Figure 7



(a) Elevated private reservoir or gravity tank

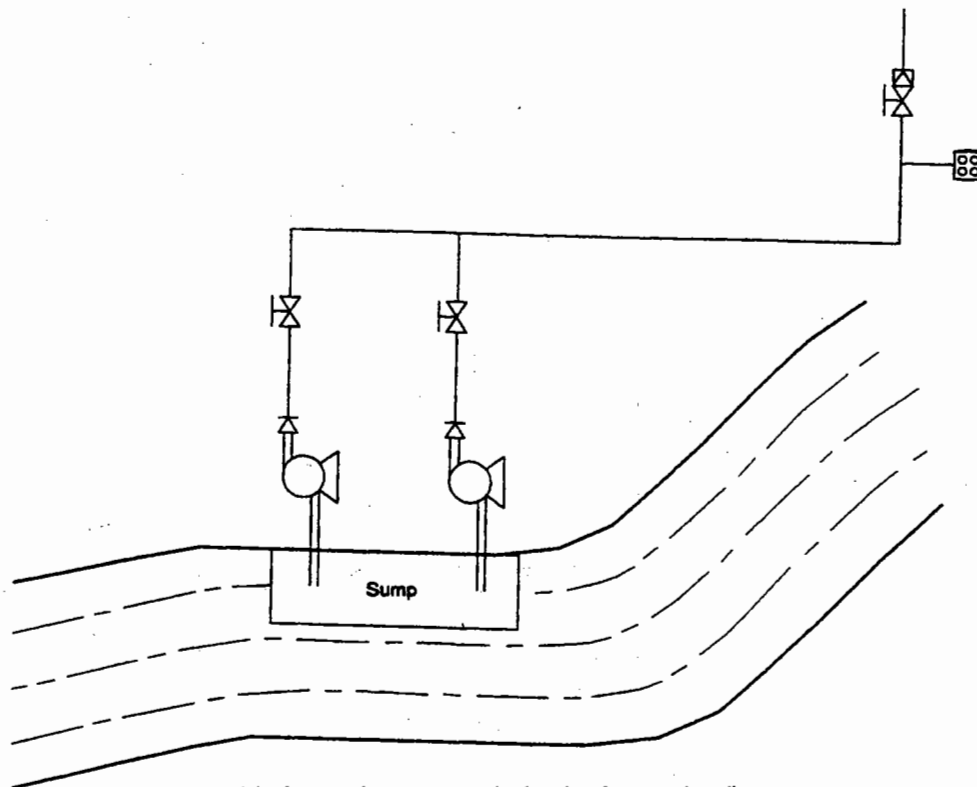


Note 1: Highest sprinkler is > 60 m above ground

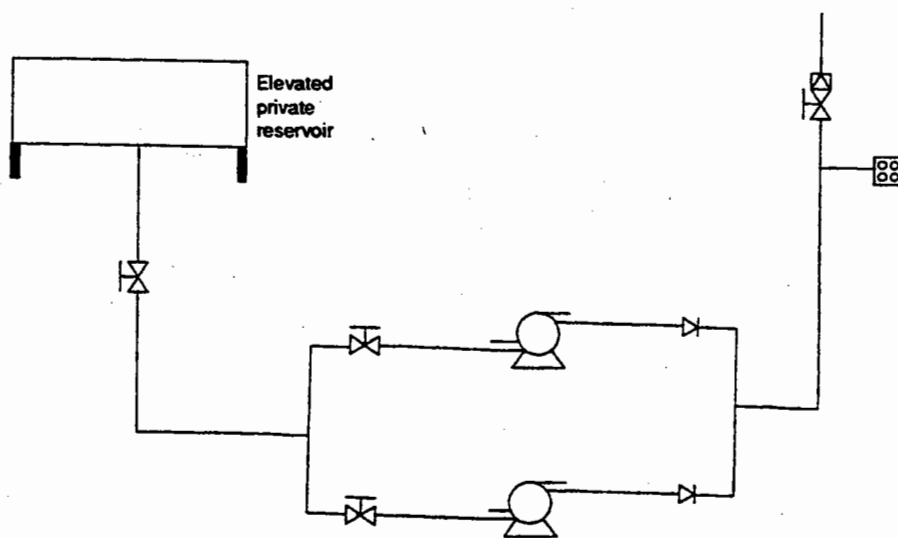
Note 2: Highest sprinkler is < 60 m above ground

(b) Automatic pump supply drawing from a pump suction tank

Figure 7 – Typical water supplies

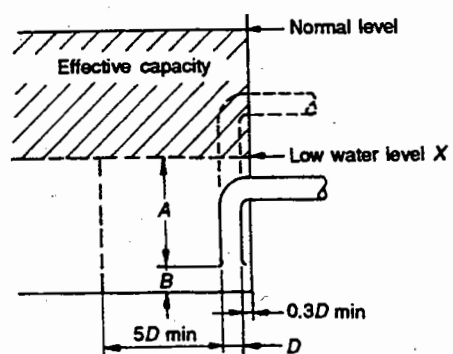


(c) Automatic pump supply drawing from a virtually inexhaustible source such as river, etc.

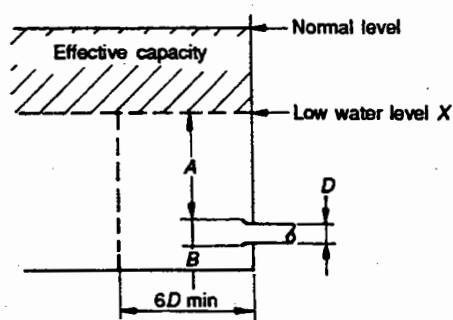


(d) Automatic (booster) pump supply drawing from an elevated private reservoir

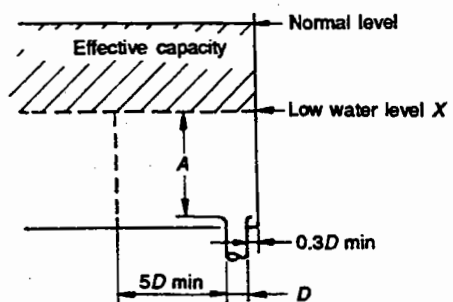
Figure 7 – Typical water supplies (continued)



(a)

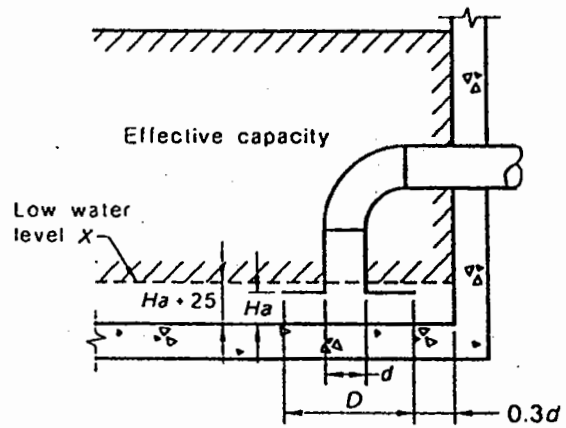


(b)

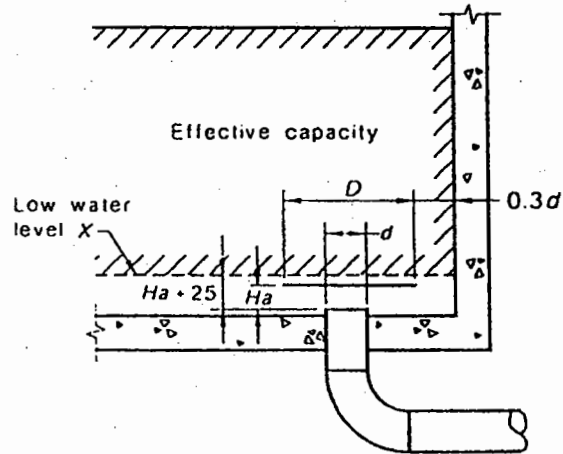


(c)

Figure 8 – Effective capacity of pump suction tanks



(a) Suction from side of tank



(b) Suction from bottom of tank

Figure 9 – Vortex inhibitors

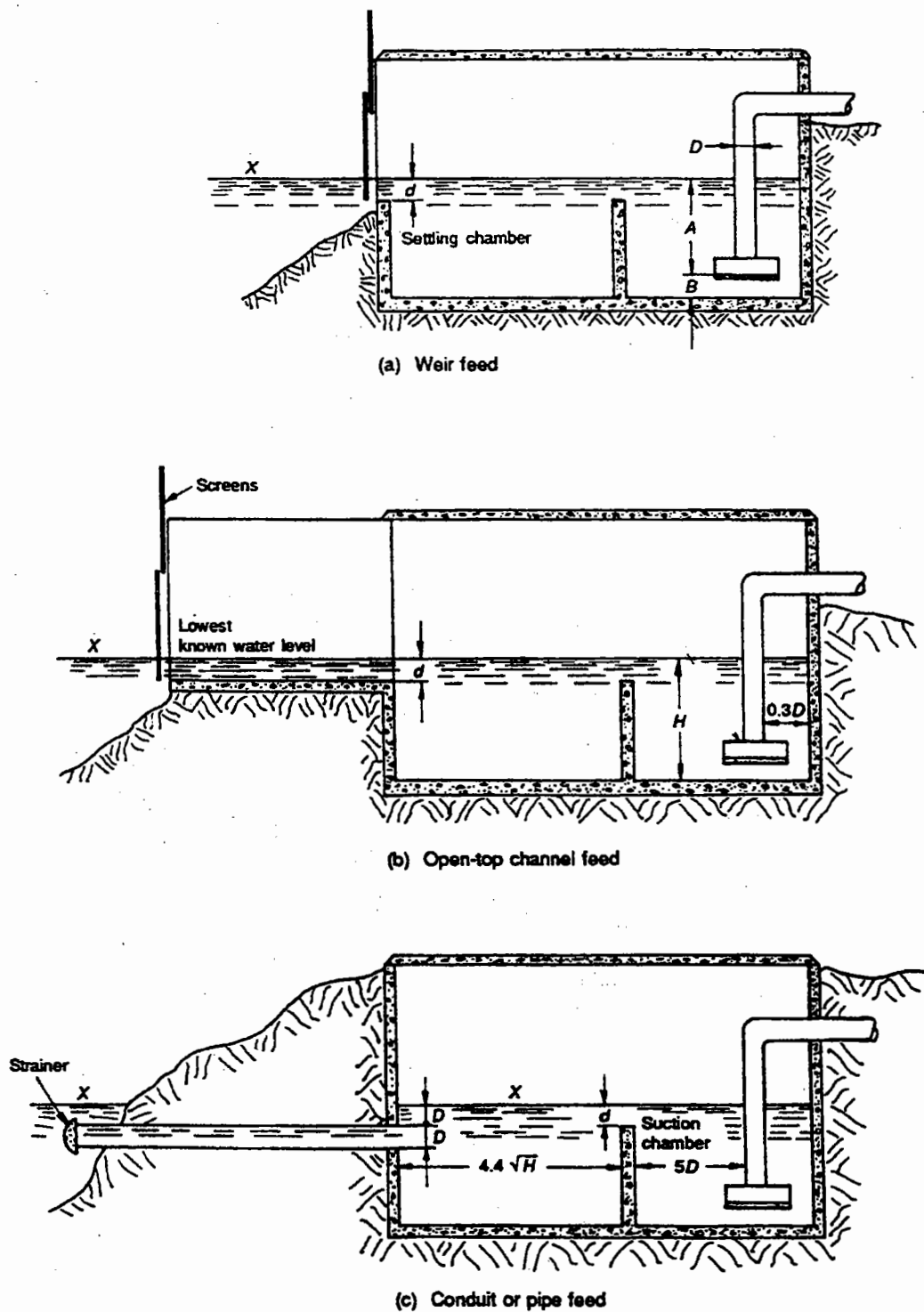


Figure 10 – Minimum dimensions for supplies from inexhaustible source

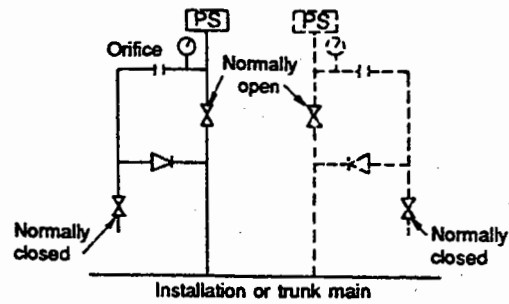


Figure 11 – Typical pressure switch test arrangement

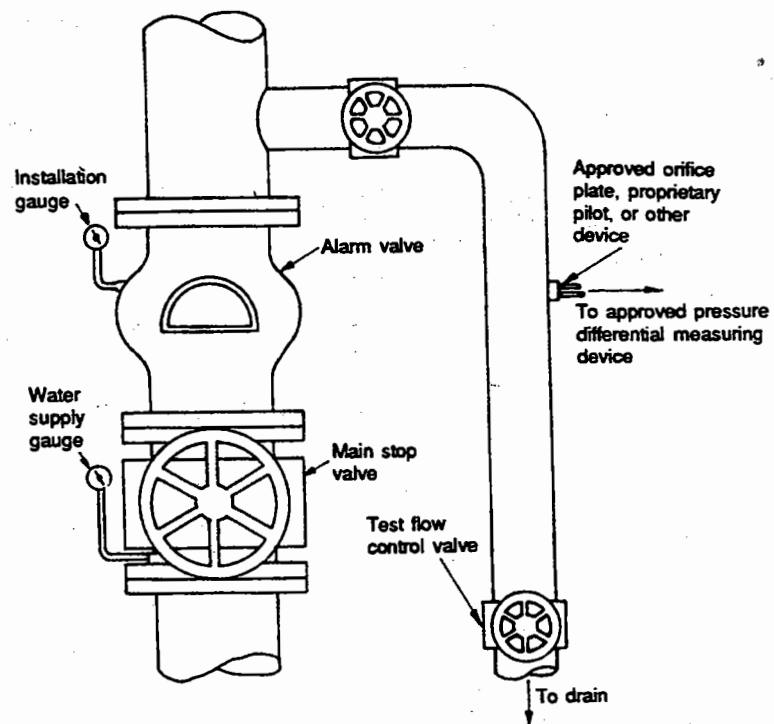
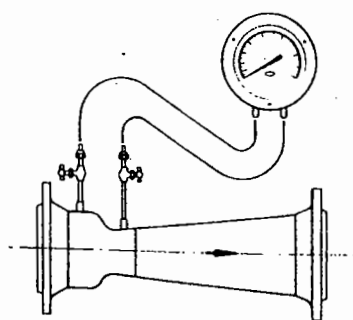
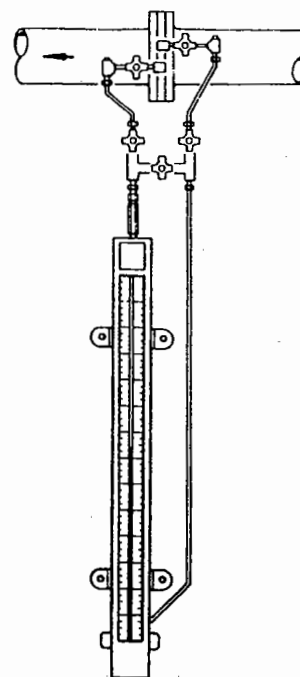


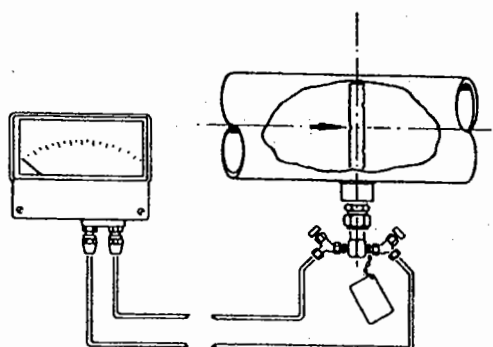
Figure 12 – Typical layout for proving water supplies



(a) Venturi with direct-reading meter

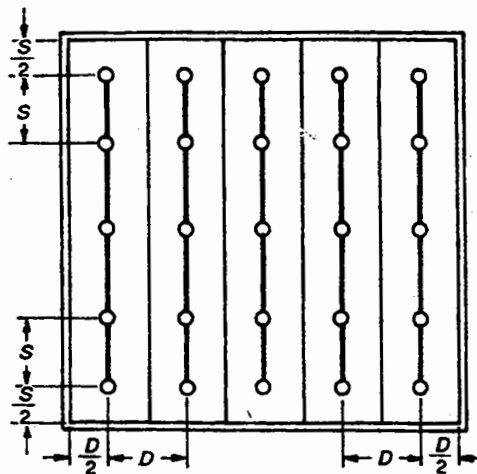


(b) Orifice plate and manometer



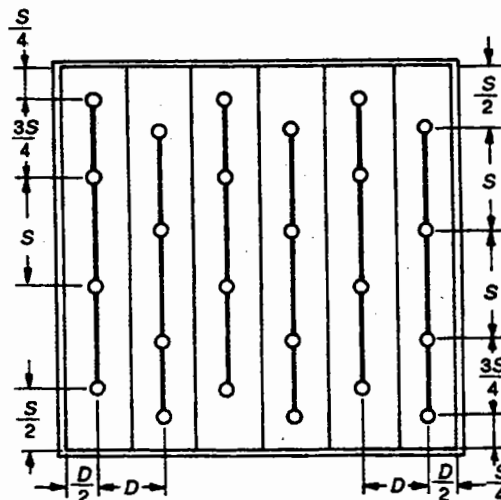
(c) Pitot tube with direct-reading meter

Figure 13 – Typical flow-measuring devices



- S (spacing of sprinklers) = 4.6 m max. for light hazard
 D (distance between rows) = 4.2 m max. for ordinary hazard
 = 3.7 m max. for high hazard
 S x D = 21 m² max. for light hazard
 = 12 m² max. for ordinary hazard
 = 9 m² max. for high hazard (see Note to 12.3.2)

Figure 14 – Standard spacing



- S (spacing of sprinklers) = 4.6 m max. for ordinary hazard
 D (distance between rows) = 4.2 m max. for ordinary hazard
 = 3.7 m max. for high hazard
 S x D = 12 m² max. for light hazard

(Illustrating acceptable staggered arrangement for ordinary hazard where it is desired to space sprinklers more than 4.2 m apart on range pipes)

Figure 15 – Staggered spacing

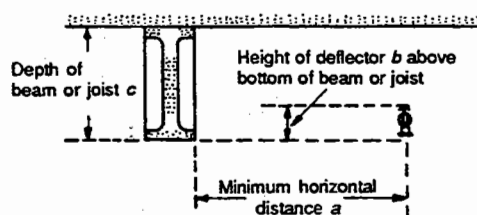


Figure 16(a) – Sprinkler distances from beams and joists

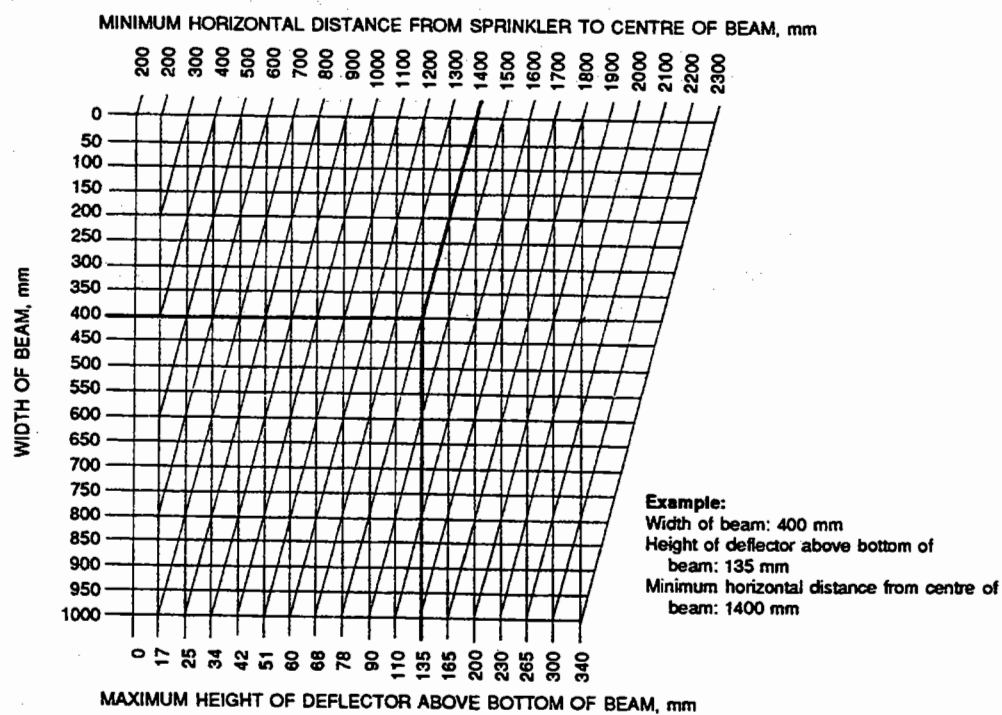


Figure 16(b) – Conventional sprinklers installed upright

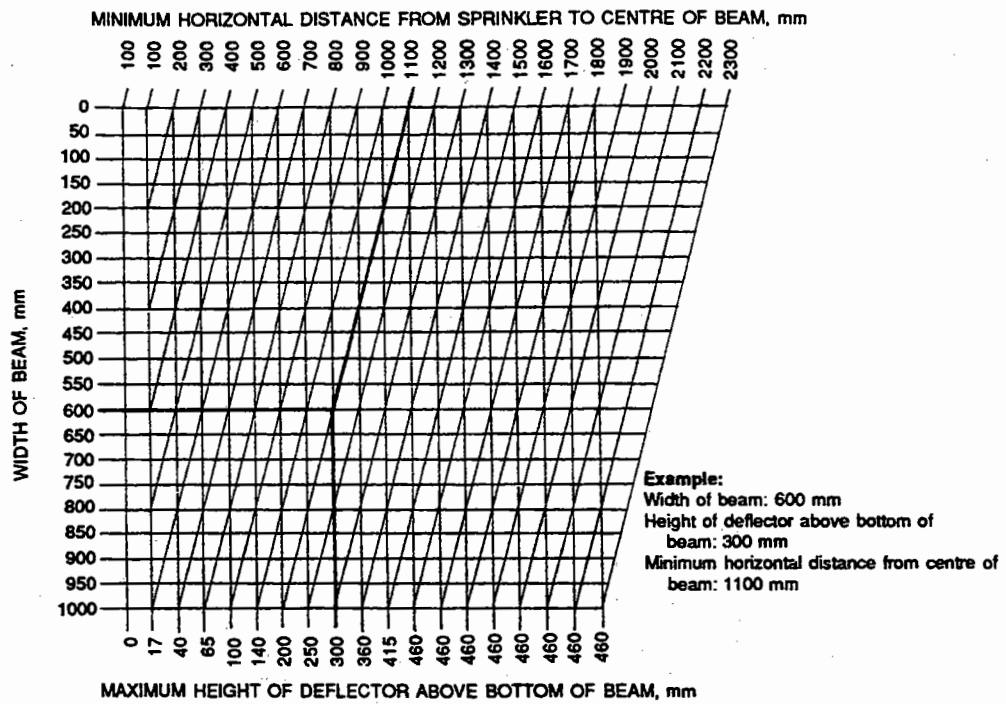


Figure 16(c) – Spray sprinklers (upright and pendent types) and conventional sprinklers installed pendent

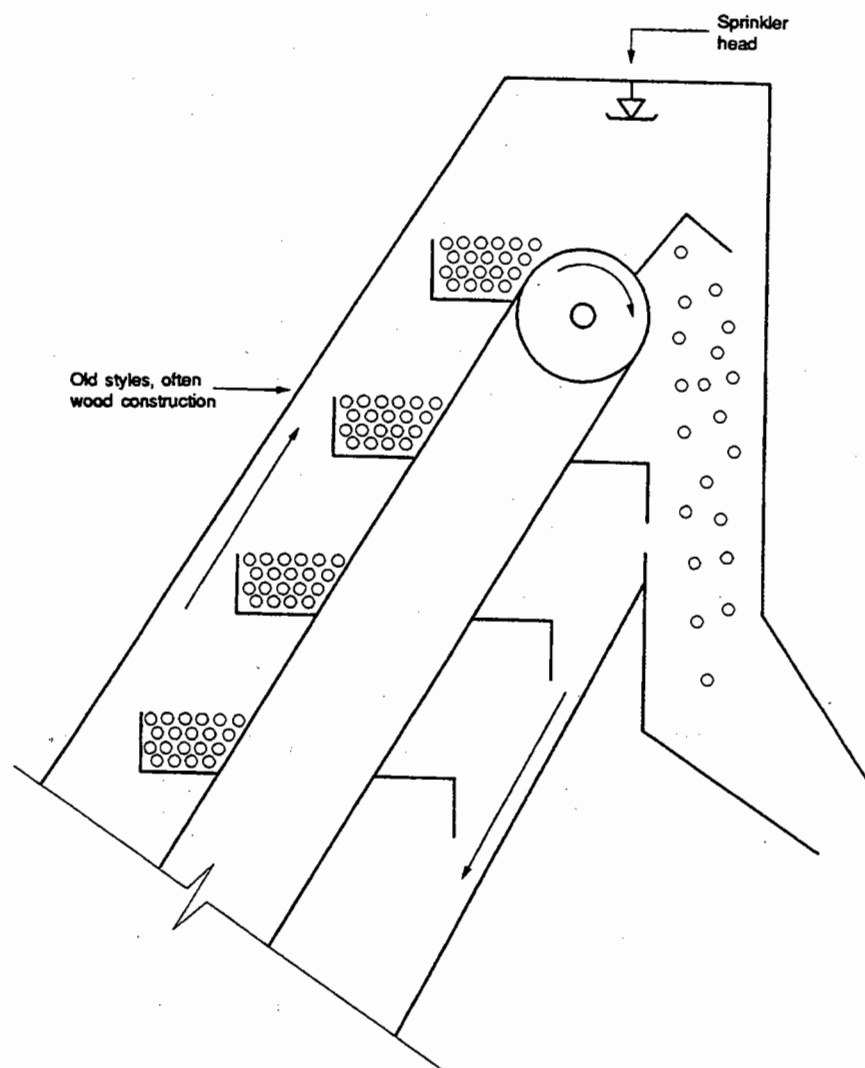


Figure 17 – Typical grain elevator

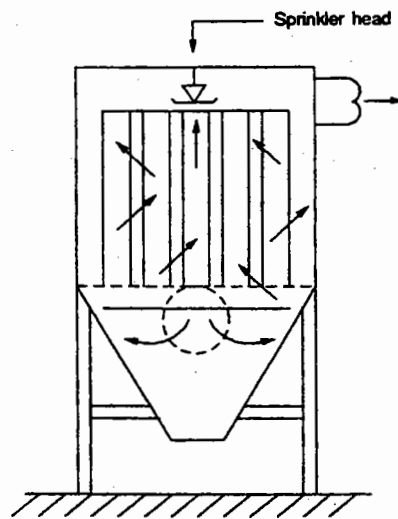


Figure 18 – Bag type dust receiver

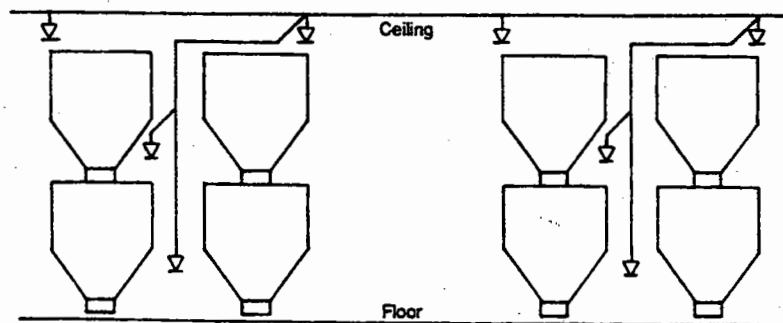


Figure 19 – Machines in tiers

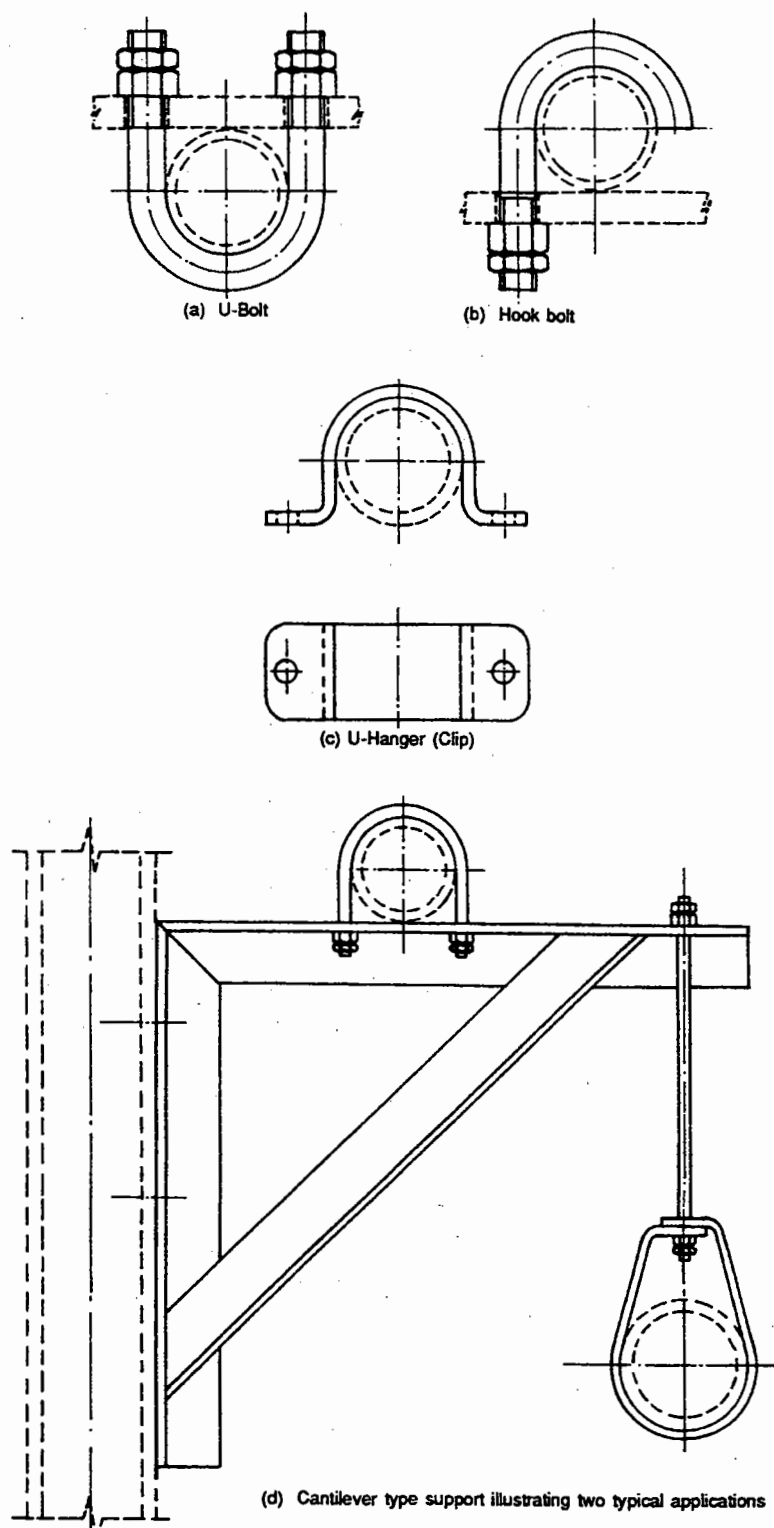
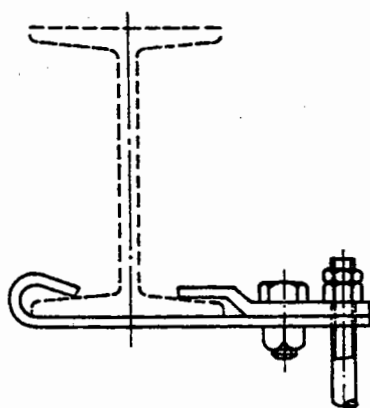
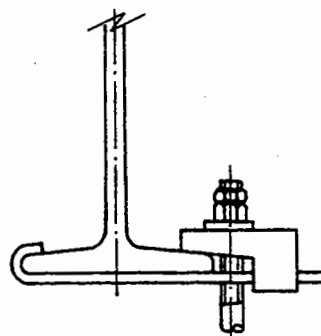


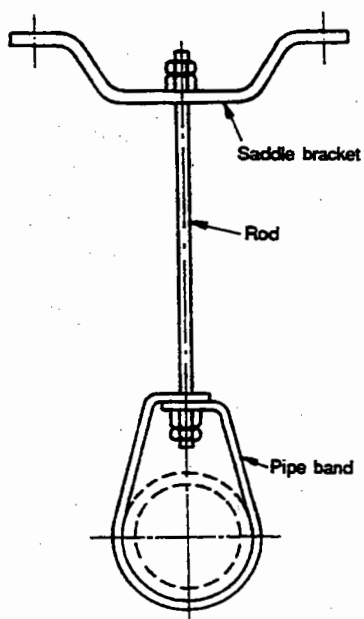
Figure 20 – Typical pipe support components



(e) (i) Girder or beam clamp

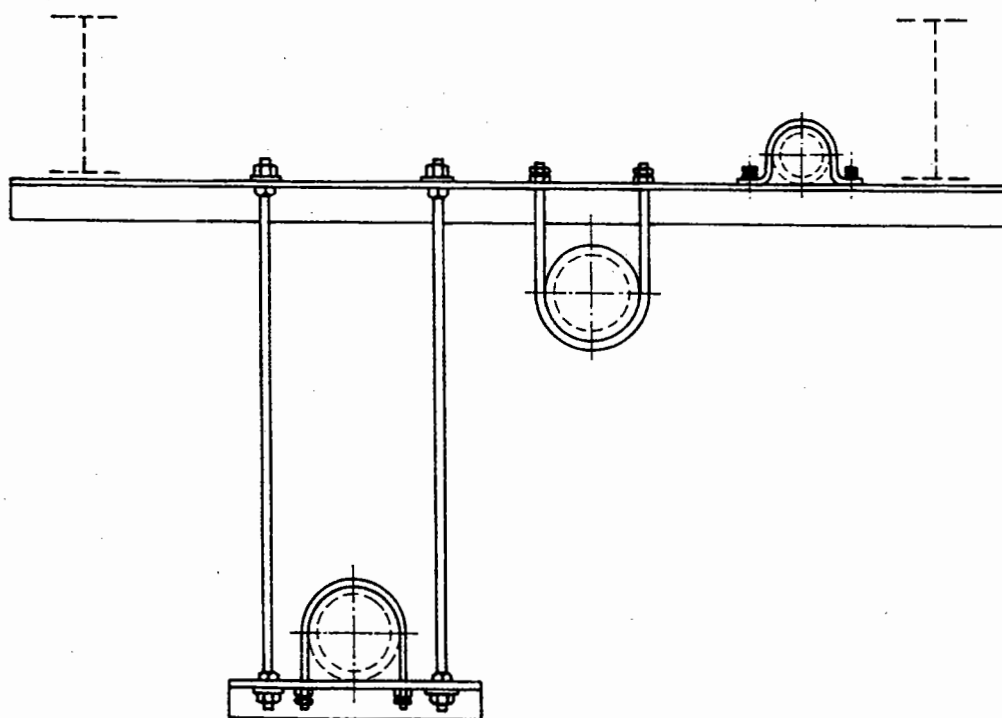


(e) (ii) Girder or beam clamp



(f) Saddle bracket, rod and pipe band

Figure 20 – Typical pipe support components (continued)



(g) Pipe support beam illustrating three typical applications

Figure 20 – Typical pipe support components (continued)

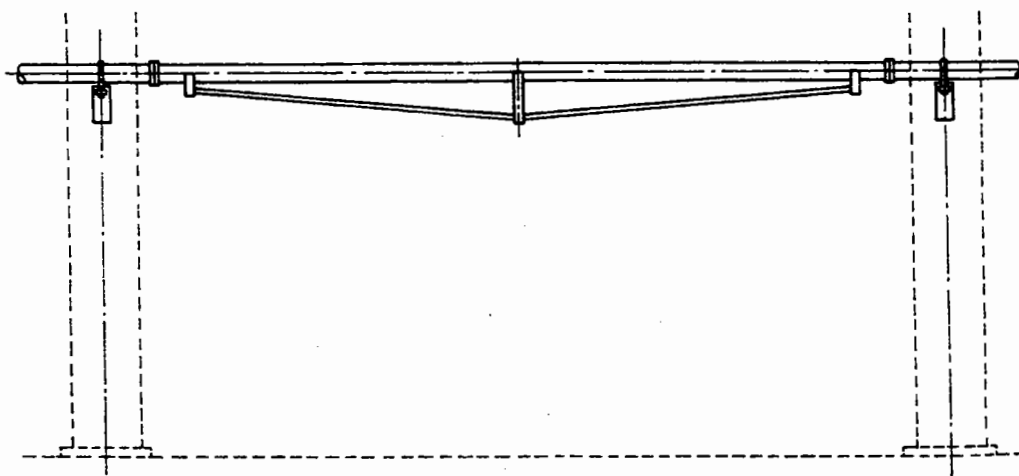


Figure 21 – Typical method of support for long span

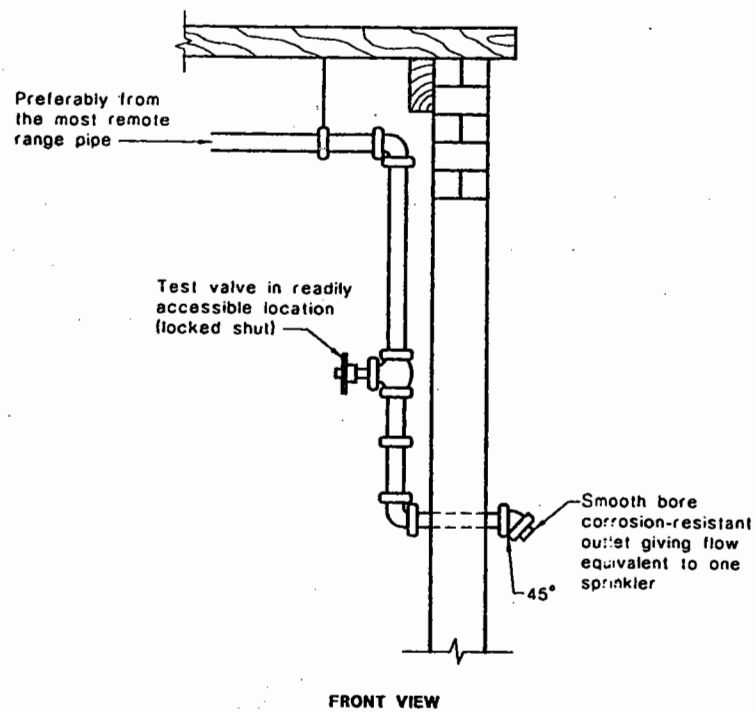
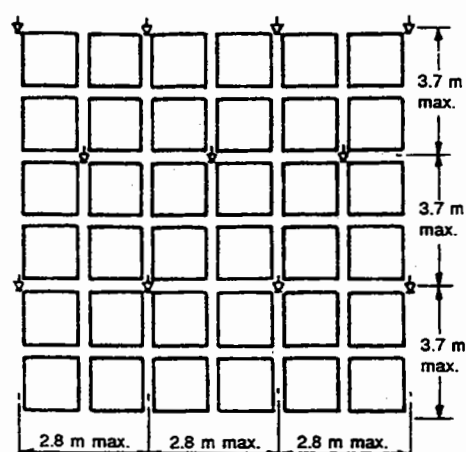
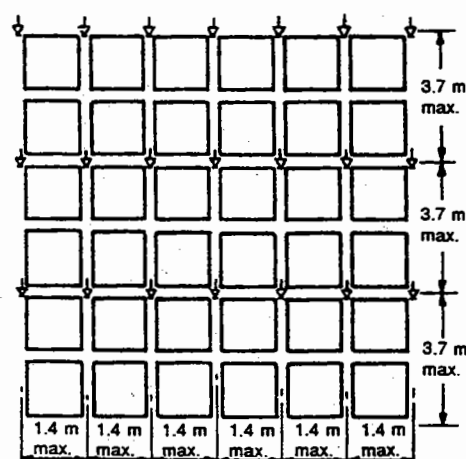


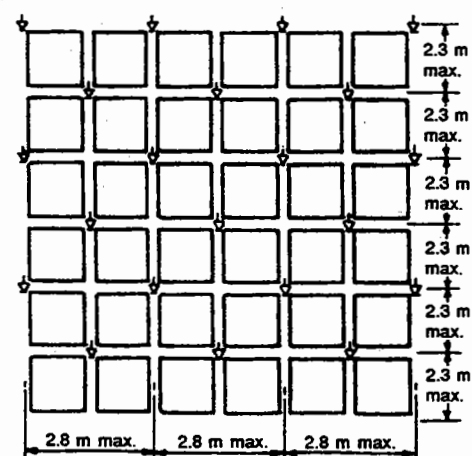
Figure 22 – Typical remote test valve



(a) Category I or II goods

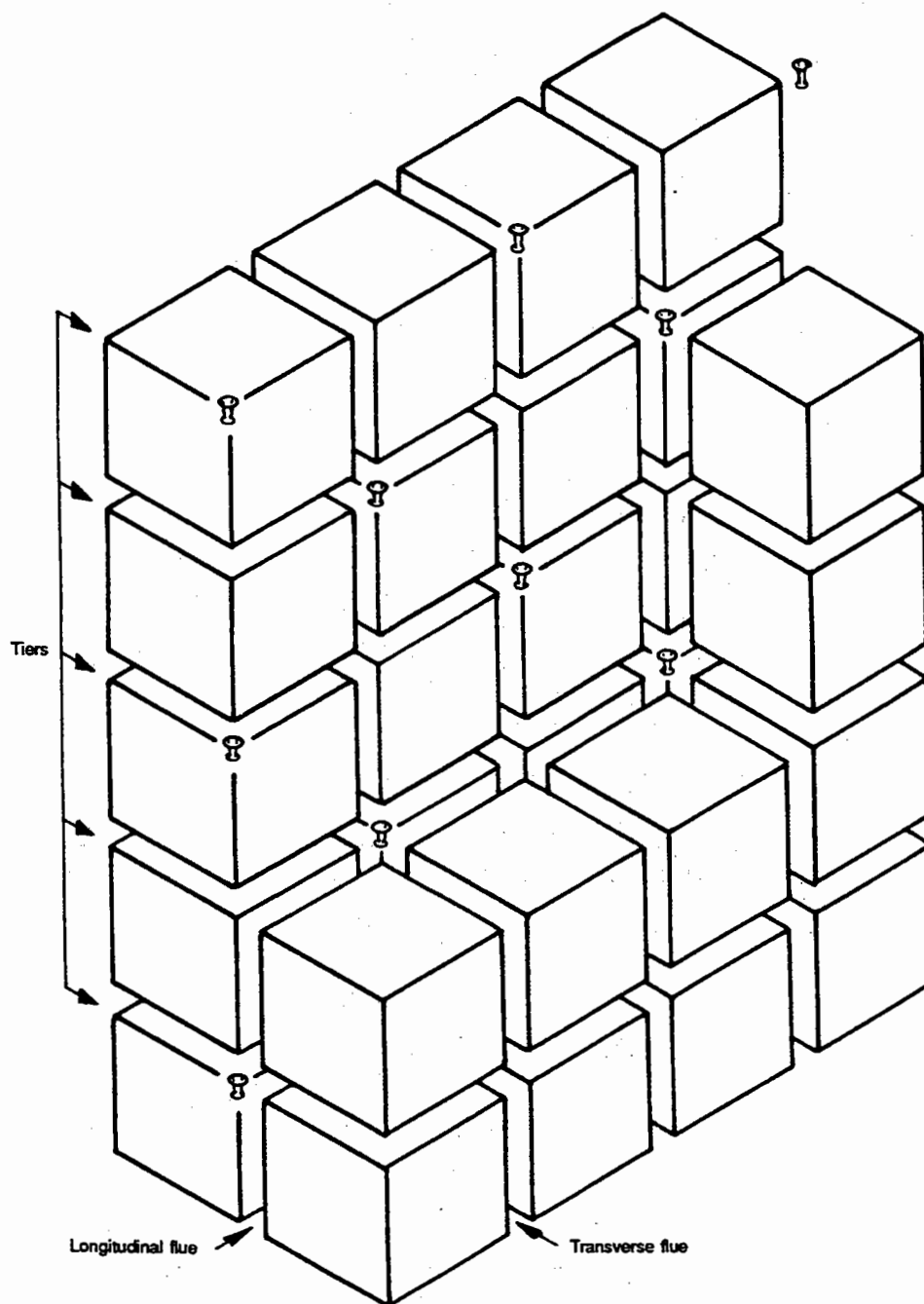


(b) Category III goods or Category I and II where they are mixed with Category III goods



(c) Category IV goods or Category I, II and III where they are mixed with Category IV goods

Figure 23 – Intermediate level protection



(d) Isometric view of typical rack – Category IV

Figure 23 – Intermediate level protection (continued)

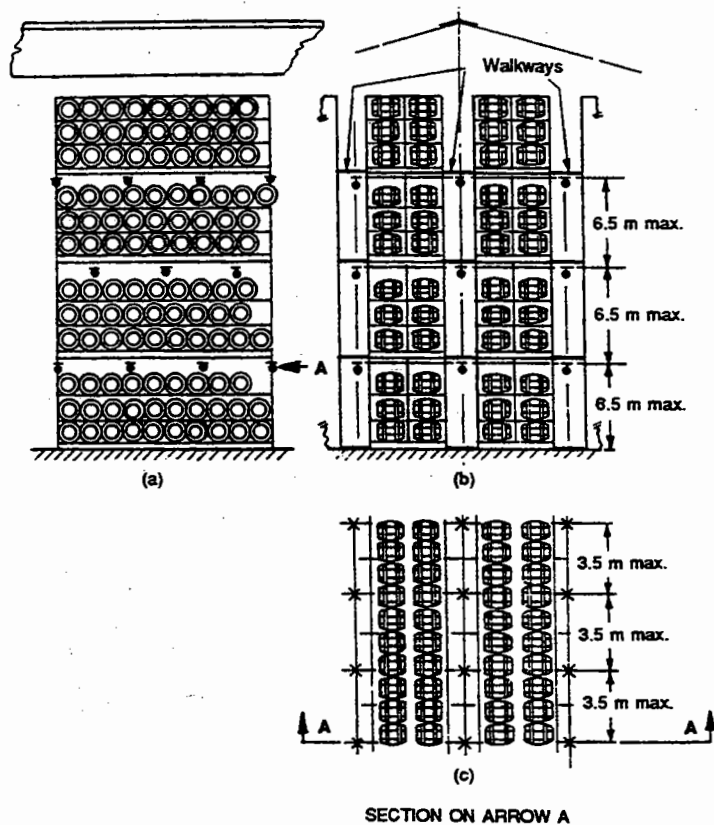


Figure 24(a) – Typical bonded stores (spirituous liquors) – double rack storage

Staggered arrangement of intermediate sprinklers in double rack storage with aisles between, having walkways at various levels: maximum area per sprinkler = 11 m^2

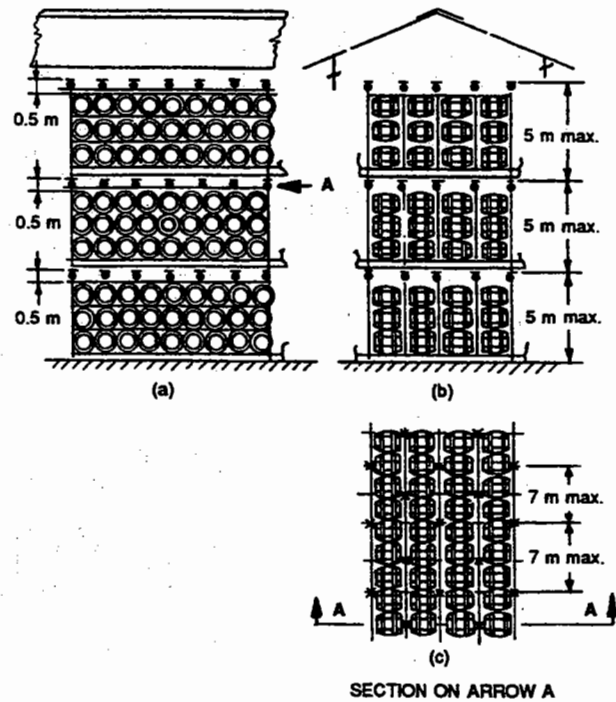


Figure 24(b) – Typical bonded stores (spirituous liquors) – continuous racking

Staggered arrangement of intermediate sprinklers in continuous racking without aisles or walkways :
maximum area per sprinkler = 7 m^2

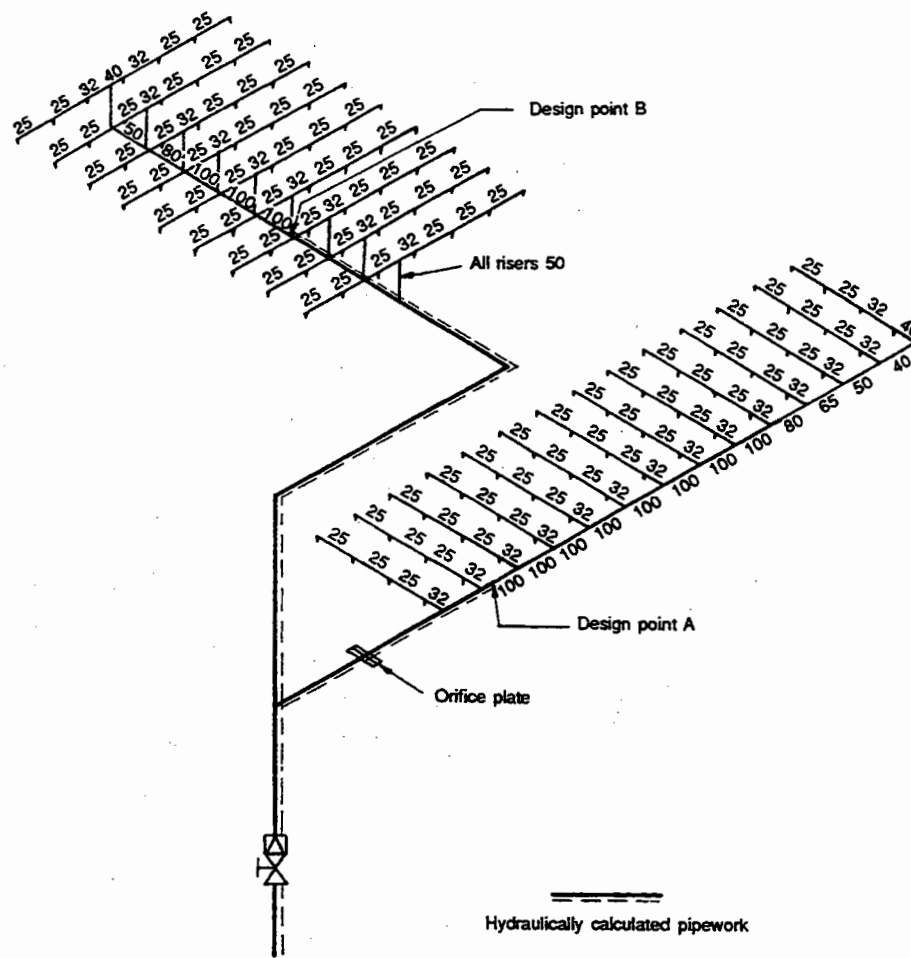


Figure 25(a) – Typical extra high hazard class system pipe sizes based on Table 25(A)

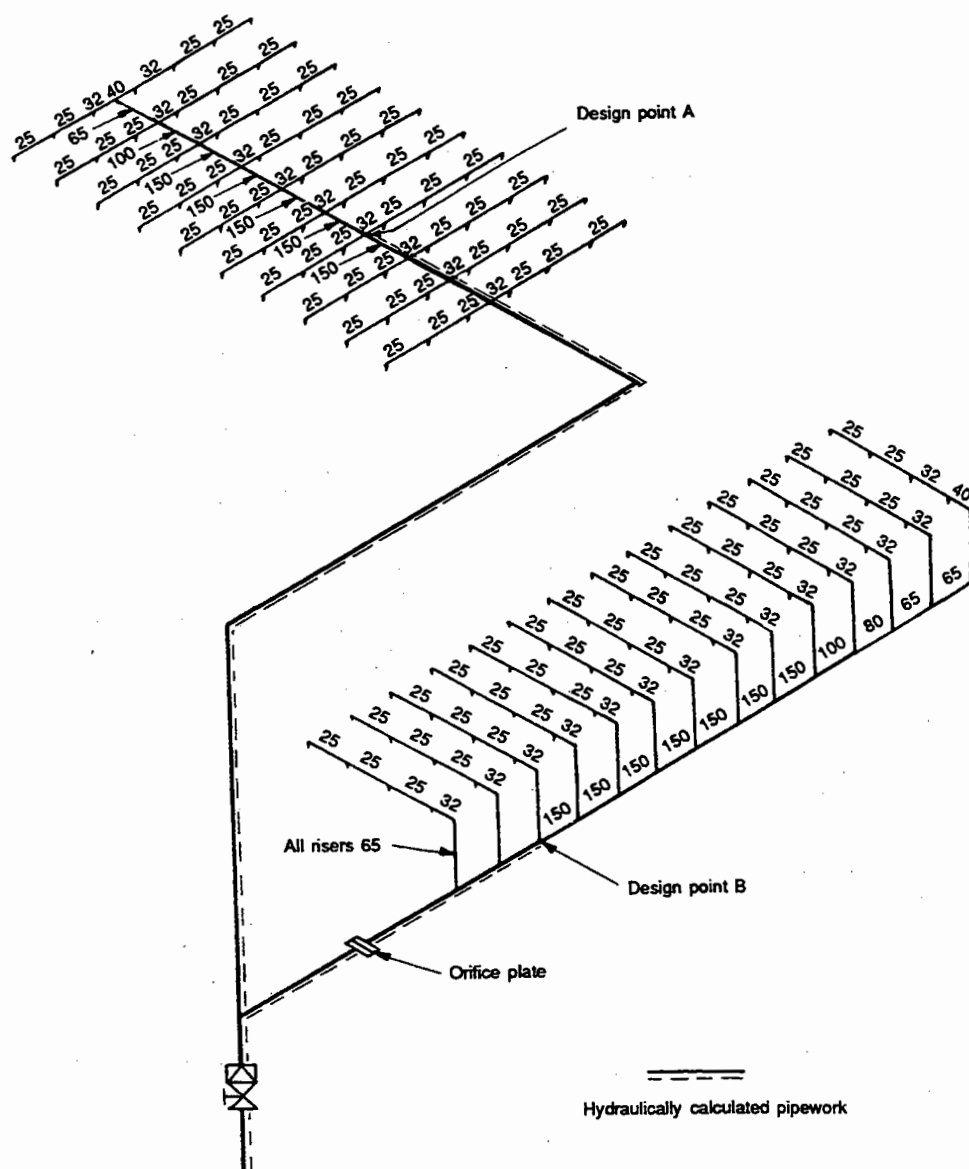


Figure 25(b) – Typical extra high hazard class system pipe sizes based on Table 25(B)

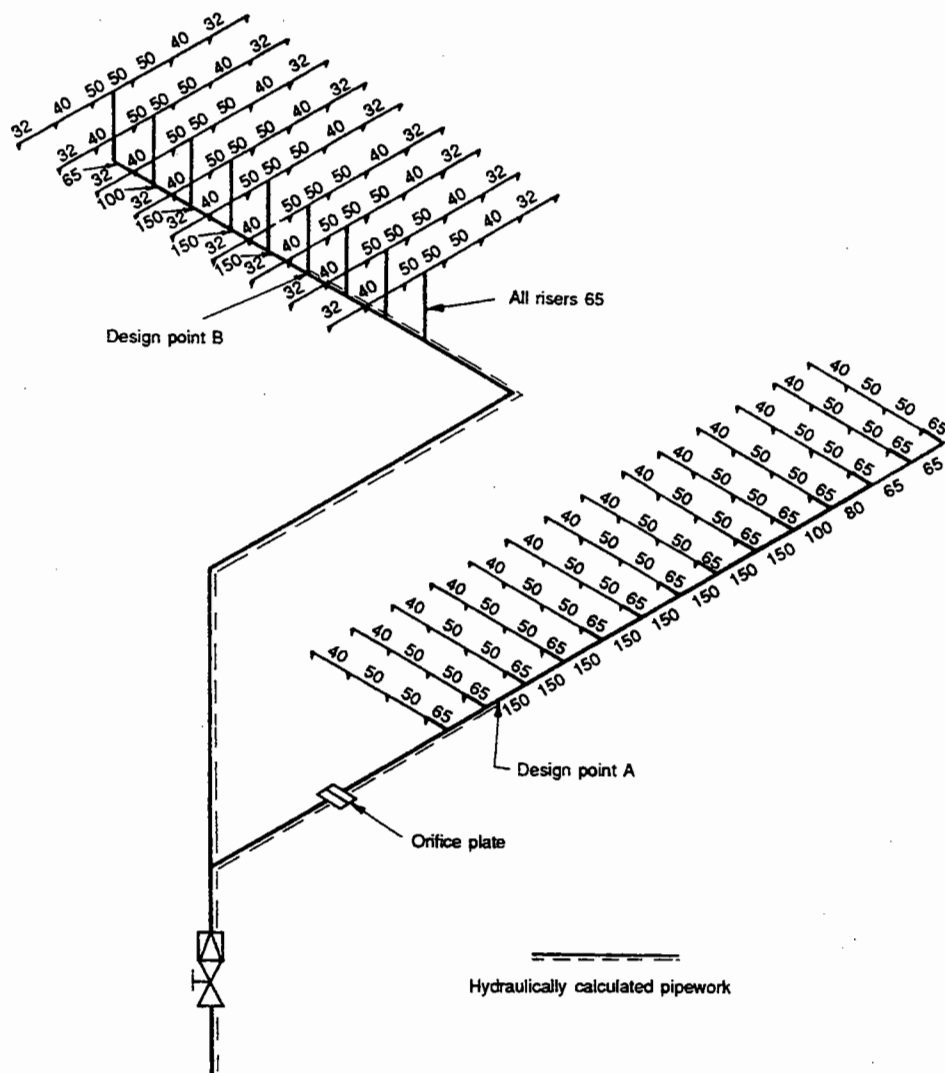
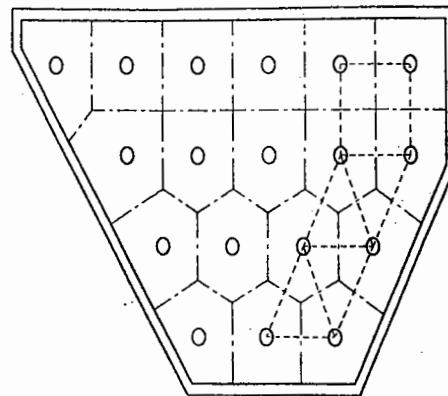


Figure 25(c) – Typical extra high hazard class system pipe sizes based on Table 25(C)



Centre-lines midway between
adjacent sprinklers at right angles
to the line joining sprinklers

Line joining sprinklers



Figure 26 – Determination of area covered per sprinkler

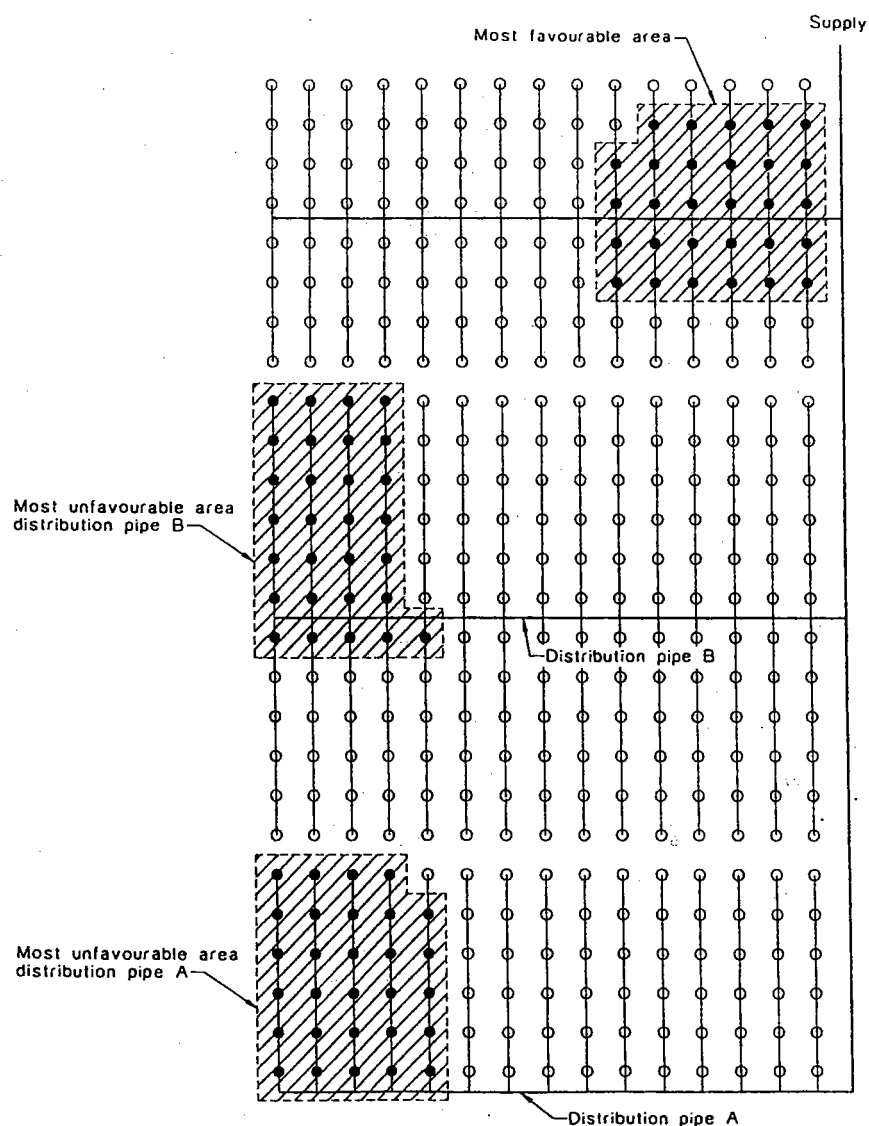


Figure 27(a) – Typical hydraulically most favourable and most unfavourable areas of operation in a terminal main system with terminal range pipes

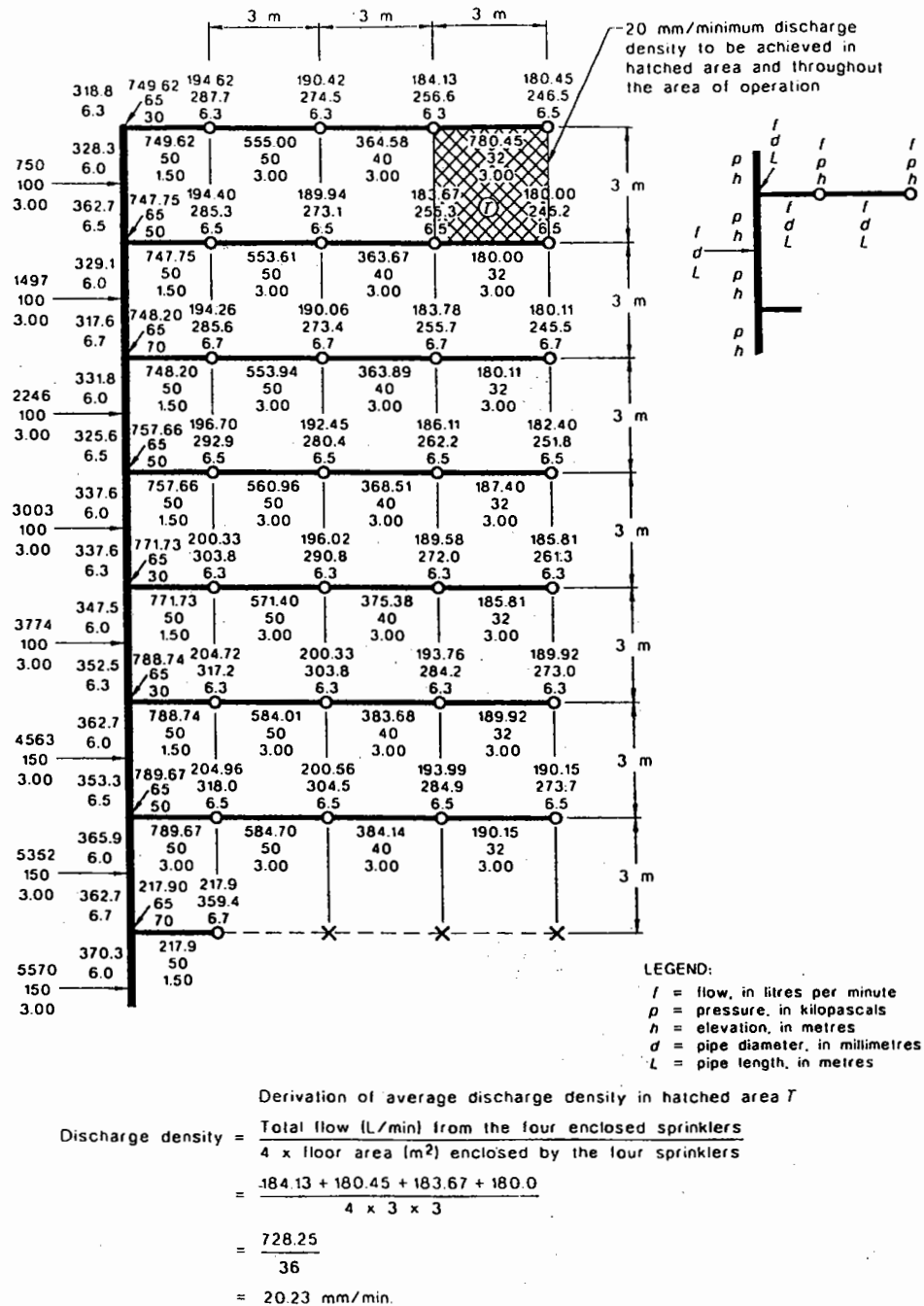


Figure 27(b) – Hydraulic design of most unfavourable area of operation assuming 20 mm/min minimum discharge density over 260 m² (see Figure 27(a))

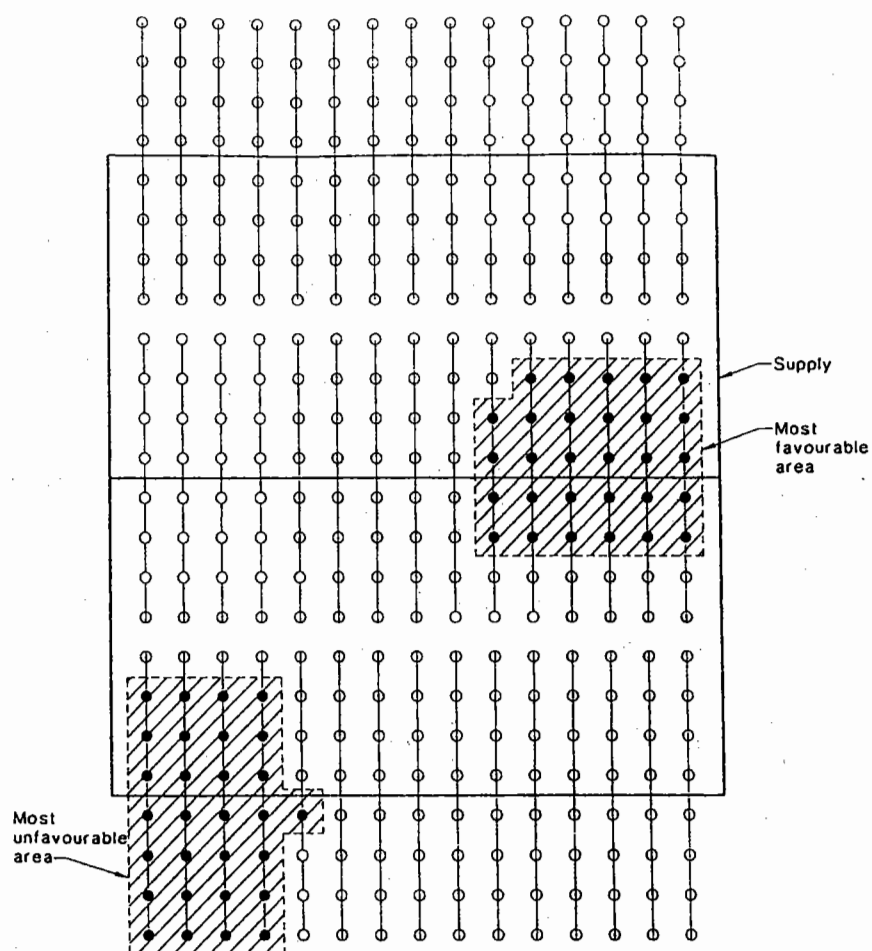
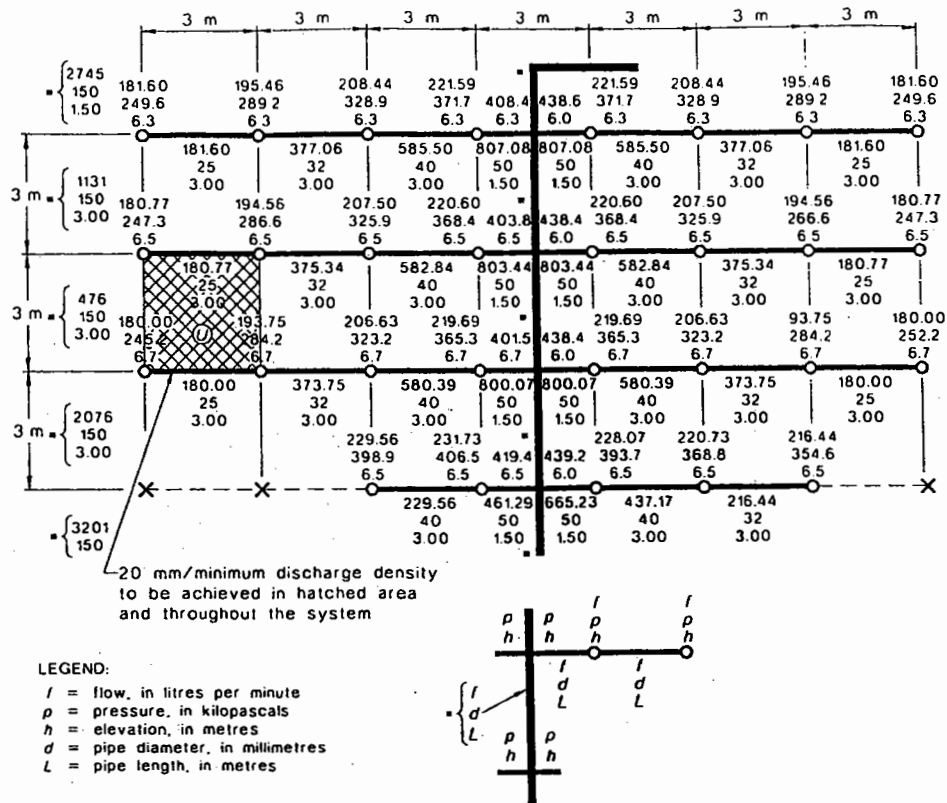


Figure 27(c) – Typical hydraulically most favourable and most unfavourable areas of operation in a terminal looped system with terminal range pipes



Derivation of average discharge density in hatched area U

$$\begin{aligned} \text{Discharge density} &= \frac{\text{Total flow (L/min) from the four enclosing sprinklers}}{4 \times \text{floor area (m}^2\text{) enclosed by the four sprinklers}} \\ &= \frac{180.77 + 194.57 + 180.00 + 193.75}{4 \times 3 \times 3} \\ &= \frac{749.09}{36} \\ &= 20.81 \text{ mm/min.} \end{aligned}$$

Figure 27(d) – Hydraulic design of most unfavourable area of operation assuming 20mm/min minimum discharge density over 260 m² (see Figure 27(c))

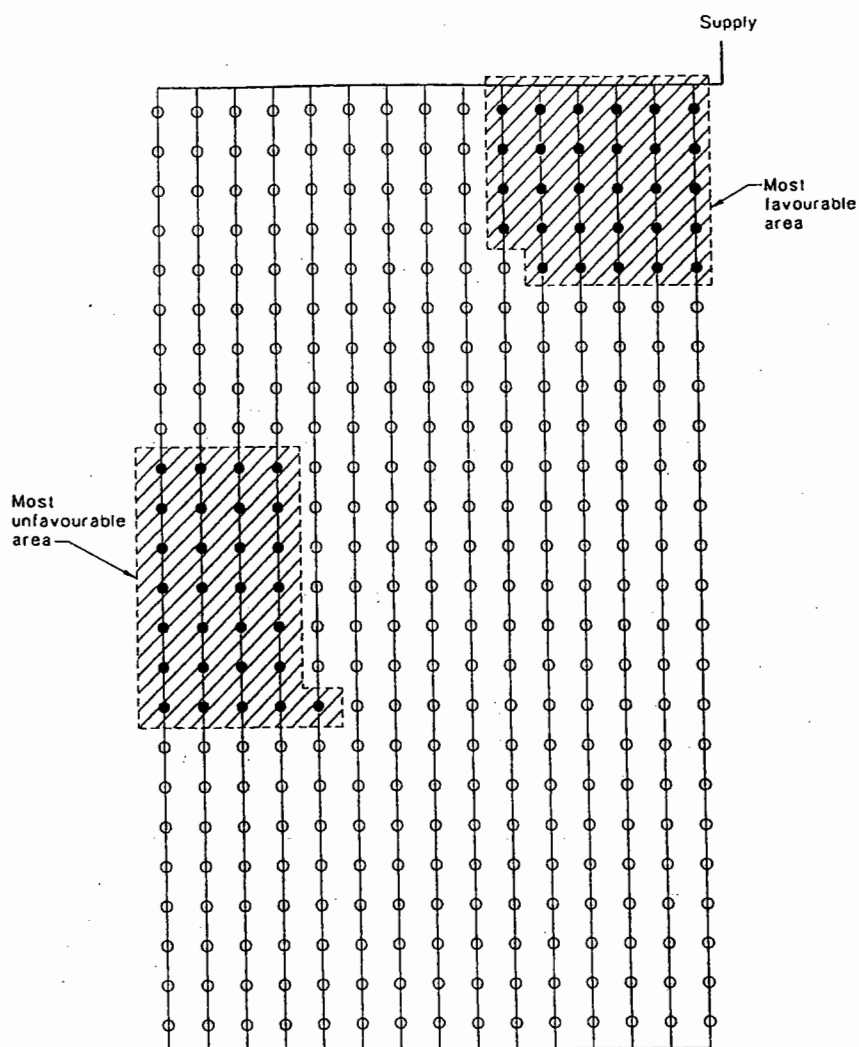
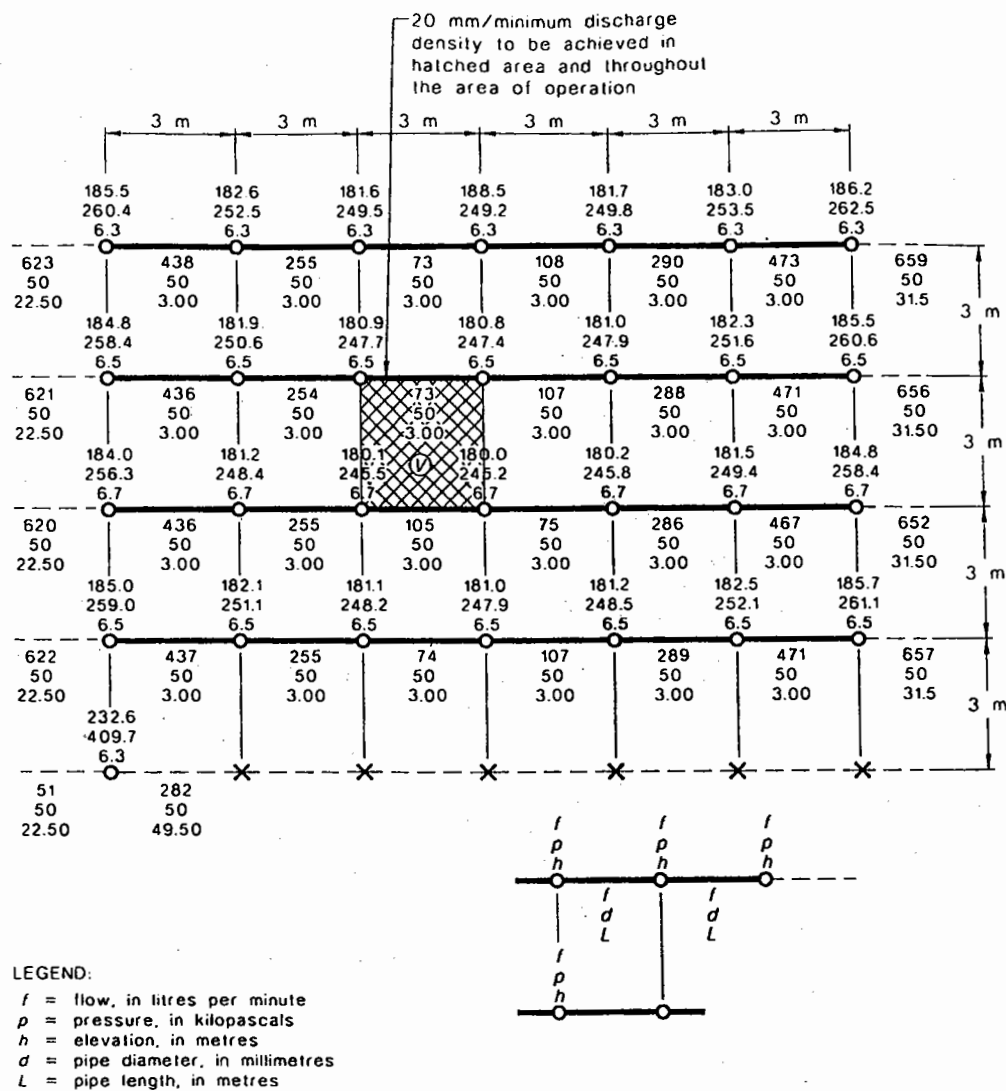


Figure 27(e) – Typical hydraulically most favourable and most unfavourable areas of operation in a gridded system



Derivation of average discharge density in hatched area V

$$\begin{aligned}
 \text{Discharge density} &= \frac{\text{Total flow (L/min) from the four enclosing sprinklers}}{4 \times \text{floor area (m}^2\text{) enclosed by the four sprinklers}} \\
 &= \frac{180.90 + 180.80 + 180.10 + 180.00}{4 \times 3 \times 3} \\
 &= \frac{721.80}{36} \\
 &= 20.05 \text{ mm/min.}
 \end{aligned}$$

Figure 27(f) – Hydraulic design of most unfavourable area of operation assuming 20mm/min minimum discharge density of over 260 m² (see Figure 27(e))

Reference number and date installed

Annex A

Orifice plates

A.1 Scope

Table 31 and 32 have been produced to assist in calculating the appropriate diameter of orifice to achieve the desired hydraulic balance mentioned in 8.14 and 12.4.2.5.

The tables indicate the correct orifice diameter in respect of pipe sizes from 50 mm to 200 mm for discrete values of pressure loss (P.) in kilopascals for an assumed rate of flow (Q.) in litres per minute. Table 31 for the smaller diameter pipes is based on a flow of 500 L/min and Table 32 for the larger diameter pipes is based on a flow of 5000 L/min.

The K factor referred to in the last column of Tables 31 and 32 is the constant in the following formula:

$$K = Q/\sqrt{P}$$

where P is the pressure loss in kilopascals due to the orifice with a rate of flow of water Q L/min.

The pressure loss produced by the orifice plate in the net pressure across the orifice and not the pressure difference measured at 'flange', 'corner' or 'D and D/2' tapping points.

A.2 Requirements

Orifice plates shall be of brass with plain central holes without burrs and of thickness specified in Table 33. They shall be located not less than two pipe diameters from any elbow or bend, measured in the direction of flow. They shall have a projecting identification tag which shall be readily visible, and on which shall be stamped the nominal pipe diameter and K factor of the orifice.

A.3 Notes on the use of Table 31 and 32

To select an orifice plate which will produce a pressure loss of P. kPa with a rate of flow of Q L/min, calculate the value of P₀ from the following formulae and refer to the appropriate table for the correct orifice diameter. Interpolate as necessary.

- a) Pipe sizes 50 and 65:

$$P_0 = P_x (500/Q_x)^2$$

- b) Pipe sizes 80, 100, 150 and 200:

$$P_0 = P_x (5000/Q_x)^2$$

Table 31 – Orifice plates for pipes of sizes 50 and 65 for a flow rate of 500 L/min

Pressure loss P_0 kPa	Orifice diameter, mm		
	Nominal internal pipe size, mm		
	50	65	K factor
250	25.9		31.6
225	26.5		33.3
200	27.1		35.4
175	27.9		37.8
150	28.8		40.8
125	29.6		44.7
100	30.9		50.0
90	31.1		52.7
80	32.2	34.5	55.9
70	32.8	35.3	59.8
60	33.7	36.3	64.5
50	34.7	37.6	70.7
40	35.9	39.3	79.1
30	37.5	41.2	91.3
20	39.7	44.2	111.8
10	42.7	49.1	158.1
5		53.6	223.6

Table 32 – Orifice plates for pipes of sizes 80, 100, 150 and 200 for a flow rate of 5000 L/min

Pressure loss P_0 kPa	Orifice diameter, mm				
	Nominal internal pipe size, mm				
	80	100	150	200	K factor
3500	41.9				84.5
3000	43.0				91.3
2500	44.8				100.0
2000	46.4				111.18
1500	48.9				129.1
1000	52.3	55.6			158.1
900	53.2	57.6			166.7
800	54.1	59.0			176.8
700	55.3	60.4			189.0
600	56.6	62.0			204.1
500	58.2	63.9			223.6
400	59.3	66.5			250.0
300	62.0	69.7			288.7
200	65.0	74.2	82.3		353.6
100		81.1	95.8		500.0
90		82.2	97.1	105.7	527.0
80		83.3	99.3	108.1	559.0
70		84.4	101.7	111.1	597.6
60		85.7	104.0	113.9	645.5
50		87.0	106.8	117.7	707.1
40			110.1	122.2	790.6
30			115.1	129.1	912.9
20			120.6	137.7	1118.0
10				152.6	1581.0
5				165.8	2236.0

Table 33 – Orifice plate thickness

Nominal internal pipe size mm	Orifice plate thickness mm
50	3
65	3
80	3
100	6
150	6
200	6

Annex B

Pipework interpretations

The figures in this Annex are included to clarify the terminology applied to pipework.

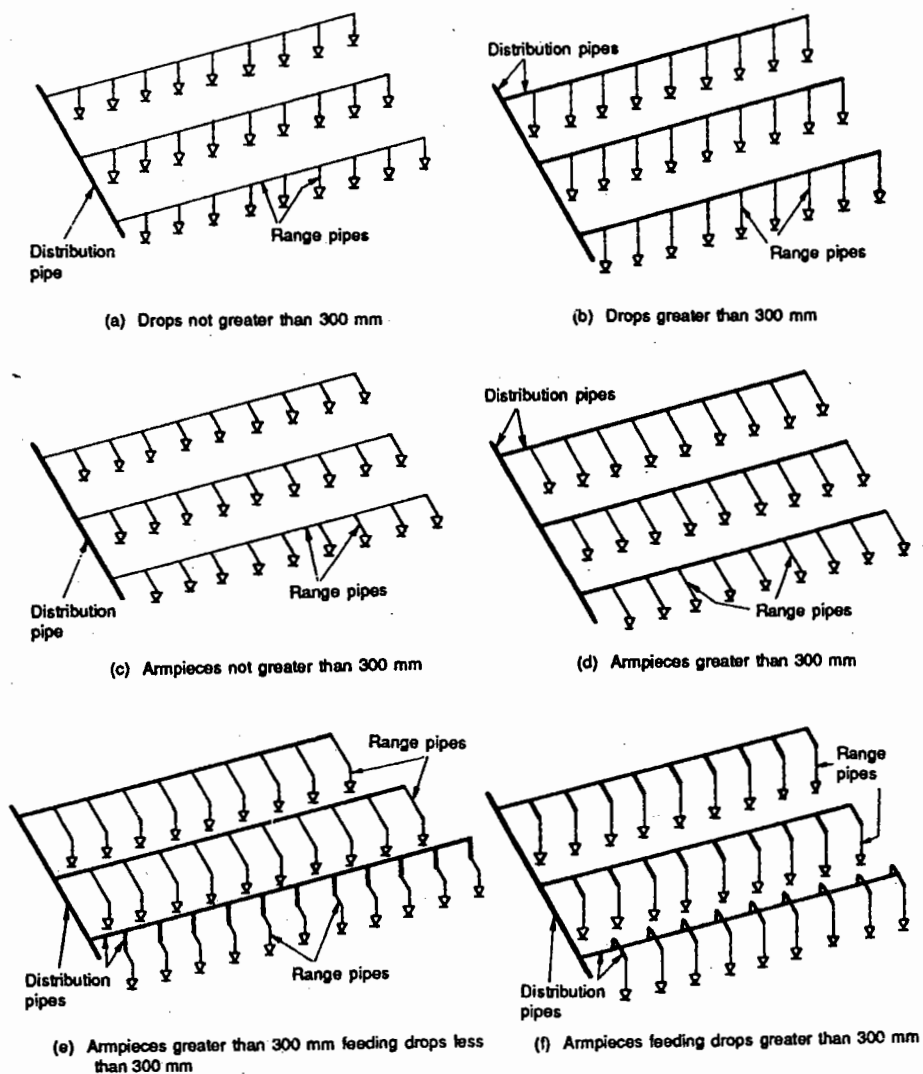
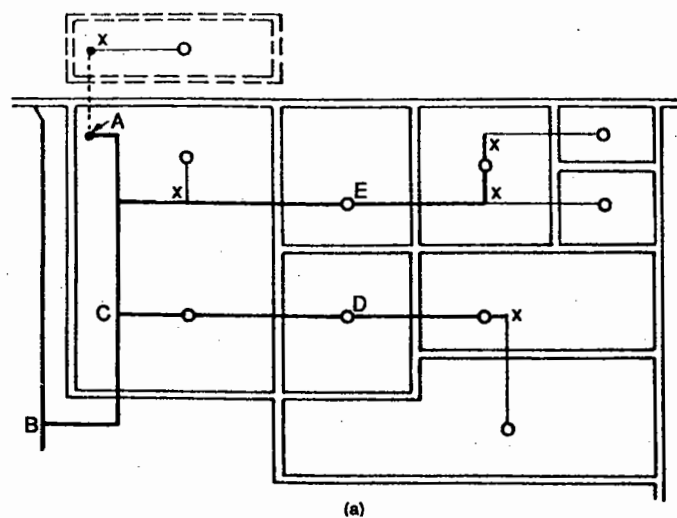
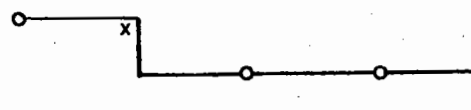


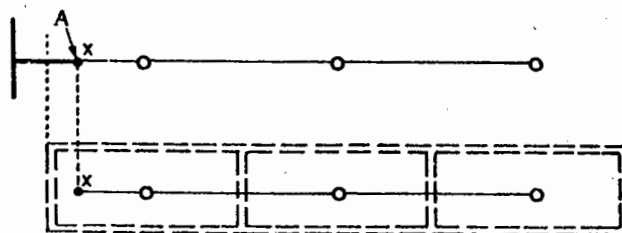
Figure 29 – Ordinary and high hazard – arm pieces and risers (or drops)



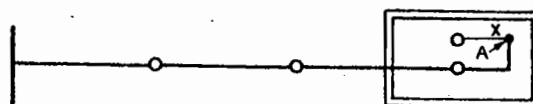
C is design point of the separate array
 D or E could have a maximum of 18 sprinklers
 B to C to be based on 70 L/min per sprinkler (Total 700L/min)
 Valves to B 1800 L/min (flow rates quoted apply to Ordinary Hazard)



(b) Branch exceeding 300 mm



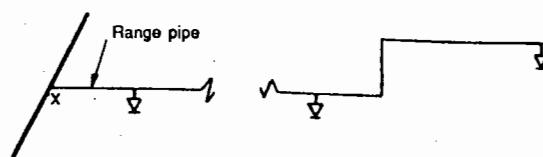
(c) Low-level rooms



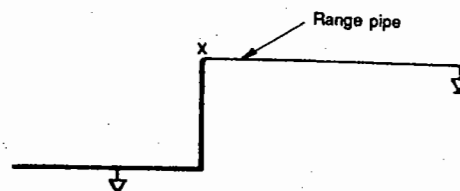
(d) Drop to low-level room

All drops 'A' sized as distribution pipe (Figure 3 Ordinary Hazard)
 Pipework downstream of points 'x' considered range pipe
 Maximum length of 25 mm pipe – 15 m

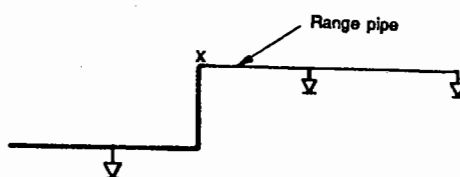
Figure 30 – Ordinary and high hazard – armpieces and risers (or drops)



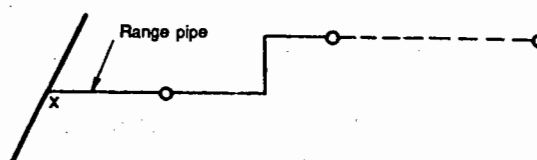
(a) Riser (or drop) not greater than 300 mm



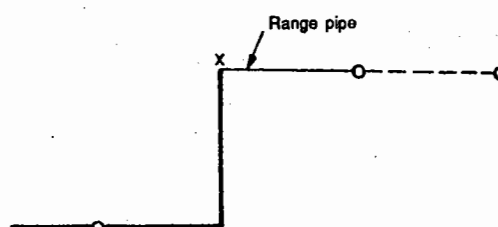
(b) Riser (or drop) greater than 300 mm



(c) Riser (or drop) of any length



(d) Arm piece not greater than 300 mm



(e) Arm piece greater than 300 mm

Pipework downstream of point 'x' is considered range pipe

Figure 31 – Ordinary and high hazard – arm pieces and risers (or drops)

Annex C

Maintenance

C.1 General

It is the responsibility of the owner of the protected building to ensure that the installation is tested in accordance with the requirements specified in this code and with any additional tests which may be required by the relevant authority.

Regular inspection and proper maintenance of the installation are necessary to ensure full operating condition and satisfactory performance of the system at all times. Such inspection, maintenance and testing of the installation shall be carried out by competent and experienced personnel who shall be thoroughly trained in the functions they are expected to perform.

Inspections, tests and maintenance work performed shall be fully recorded in a log book and shall be available for examination by the relevant authority.

For every periodic testing, the relevant authority shall be contacted prior to the transmitting of the fire call, to warn them of the simulated fire condition to be tested. On completion of the test, the relevant authority shall be contacted to ensure that the fire call was received and to advise them that the installation was reset and left in an operative condition.

At the completion of all periodic tests, the system shall be reset and verified as being in operative condition.

C.2 Precautions to be taken when an installation is to be rendered inoperative

The following precaution shall be taken before an installation is rendered inoperative.

- a) The relevant authority shall be notified before rendering a sprinkler installation inoperative.
- b) Before the water is turned off, a thorough examination of every part of the premises shall be made to ensure that the risk of fire outbreak is minimised.
- c) Where operations require the temporary shutting down of sprinkler protection, such operations shall be carried out during normal working hours and programmed to enable completion in the shortest possible time, and protection shall be restored as promptly as possible. If the work cannot be completed in one day particular attention should be paid to this when the premises are left each day.
- d) When an installation is rendered inoperative and likely to remain so outside working hours, all the fire extinguishing appliances shall be held in special readiness for immediate use. Extra watch service shall be placed on duty and temporary water connection should be made to the sprinkler installation where appropriate and practicable.

C.3 Weekly tests

The following check and tests should be made every week:

- a) Check water level and automatic refilling facilities of all water storage tank in the system.
- b) Check that all stop valves are secured in the open or closed position as appropriate. Particular attention shall be given to the main control valve, drain valve and test valve.

- c) Check and record the pressure at the installation gauge and water supply gauge and ensure that normal water pressure is being maintained.
- d) Check for the correct operation of the water alarm gong.
- e) Start all pumping units, by operating the test valve in a manner which will simulate fire conditions and check the following:
 - 1) Correct cut-in pressure;
 - 2) Efficient pump gland operation;
 - 3) Operation of both local and remote 'pump run' alarms; and
 - 4) Pump priming water.

On electric motor driven pumps, check the phase failure alarm and check that there is no excessive vibration or noise. Pump shall be fully operational within 30 seconds.

Run compression-ignition engine driven pumps for not less than 10 minutes and check the following items:

- 1) Water, oil and fuel leaks and for loose fittings and ancillary equipment.
 - 2) Belt drives.
 - 3) Correct operation of battery charging alternator/generator.
 - 4) Battery charger power failure alarm.
 - 5) Check batteries including terminals for cleanliness and correct level of electrolyte in each cell to ensure that they are in good serviceable condition.
 - 6) Obvious out of balance.
 - 7) Correct running speed.
 - 8) Before and after running, check water, oil and fuel levels. Top up if required.
 - 9) After running, ensure that the engine stop mechanism automatically returns to the start position.
- f) Test the interchangeability and function of the duty and standby pumps.
 - g) After testing of the pumps and resetting of the systems, check and record the pressure at the installation gauge and water supply gauge to ensure that normal water pressure is being maintained.
 - h) Check that required spare sprinklers and sprinkler spanner are on hand.
 - j) Check pump room to ensure it is kept free of combustible materials and accessible at all times.
 - k) Check the Fire Service breaching inlet to ensure it is in good condition, easily visible and accessible.

C.4 Quarterly tests

In addition to the normal weekly tests, the following additional tests shall be performed:

- a) Electric powered pump - where secondary power supplies are provided, the pump shall be run off the secondary supply. The pump shall be run for not less than 5 minutes.
- b) Compression-ignition engine driven pump - the engine shall be run at rated speed for a period of not less than 30 minutes and the operating temperature checked.
- c) Test all water flow alarm switches by operation of a 10 mm test valve to simulate fire conditions. These may be tested on a weekly rotating basis; however, each switch must be tested quarterly.
- d) Check condition of all sprinklers. Sprinkler shall be replaced when painted, corroded, damaged or loaded with foreign materials.
- e) Operate and check to ensure that all isolating valves on the PUB main connection, and any other water supply stop valves, are fully open.
- f) Check to ensure that all water supply non-return valves are correctly seated.
- g) Clean the strainer and oil the external alarm water motor and gong.
- h) Check for obstructions such as partitions, racks or piled stock which are placed as to interfere with the effectiveness of water discharging from sprinklers.

C.5 Annual tests

In addition to the normal weekly and quarterly tests, the following additional tests shall be performed:

- a) Compression-ignition engine drive pumps:
 - 1) Check, clean and replace, if required, engine fuel sludge and sediment trap, and fuel, oil and air filters; and
 - 2) Change engine oil. More frequent oil changes shall be carried out if advised by the engine manufacturer.
- b) Carry out water supply periodic check test to ensure that the water supply satisfies the pressure and flow requirements appropriate to the hazard class.
- c) Physically check the internal mechanism of all pressure switches to ensure that all components are free of corrosion, securely mounted and in working order.
- d) With electrical equipment isolated from all power supplies, the motor starter should be cleaned and the condition of all heavy-current-carrying contacts checked. Any item showing signs of wear or corrosion shall be immediately repaired or replaced.
- e) Run the electric pump for a minimum period of 30 minutes under full load conditions and check the load current per phase for variation from original test readings.
- f) Replace all sprinklers installed in hood over cooking equipment.
- g) Examine the interior and exterior of water tank, clean and paint as required.
- h) Examine all pipes and hangers for corrosion and mechanical damage. Clean, paint and replace as required. Loose hangers shall be replaced or refastened.

- i) Oil or grease all valve stems. Completely close and re-open the valve to test its operation and distribute the lubricant.
- j) Check all gauges with an inspection gauge.

C.6 Three-yearly tests

In addition to the normal annual tests, every three years, overhaul all stop, alarm, non-return and pressure-reducing valves. Replace all damaged and worn parts as necessary.

Where investigation suggests that sediment may have collected in the pipework, all system pipework should be flushed. Conditions that may indicate the need for investigation include the following:

- a) Discharge of obstructive material during routine water tests.
- b) Foreign material in sprinkler pumps or in check valve.
- c) Heavy discoloration of water during drain tests.
- d) Plugging of sprinklers.

Standards/Publications referred to:

AS 1074	Steel tubes and tubulars for ordinary service
AS 1202	A.C. motor starters (up to and including 1000 V)
AS 1210	Pressure vessels
AS 1281	Cement mortar lining of steel pipes and fittings
AS 1349	Bourdon tube pressure and vacuum gauges
AS 1359	Rotating electrical machines – General requirements
AS 1432	Copper tubes for plumbing, gasfitting and drainage applications
AS 1516	The cement mortar lining of pipelines in situ
AS 1674	Safety in welding and allied processes
AS 1692	Tanks for flammable and combustible liquids
AS 1769	Welded stainless steel tubes for plumbing applications
AS 1775	Low voltage switchgear and controlgear – Air-break switches, isolators and fuse-combination units (up to and including 1000 V a.c. and 1200 V d.c.)
AS 1851	Maintenance of fire protection equipment
AS 1873	Powder-actuated (PA) hand-held fastening tools
AS 1939	Degrees of protection provided by enclosures for electrical equipment (IP code)
AS 2789.1	Internal combustion engines – Performance Part 1 : Engines for land, rail-traction and marine use – Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption
AS 2789.6	Internal combustion engines – Performance Part 6 : Engines for land, rail-traction and marine use – Overspeed protection
AS 2869	Specification for fuel oils for agricultural, domestic and industrial engines and boilers
AS 2941	Fixed fire protection installations – Pumpset systems
AS 3000	Electrical installations
AS 3570	Automotive diesel fuel
AS 3731	Stationary batteries – Nickel-cadmium
AS 4029	Stationary batteries – Lead-acid
ASTM D975	Standard specification for diesel fuel oils
BS 476	Fire tests on building materials and structures Part 4 Non-combustibility test for materials
BS EN 837-1	Pressure gauges Part 1 : Bourdon tube pressure gauges – Dimensions, metrology, requirements and testing
BS 1042	Measurement of fluid flow in closed conduits
BS 1780	Specification for bourdon tube pressure and vacuum gauges
BS 3974	Pipe supports Part 1 : Pipe hangers, slider and roller type supports
SS CP 5	Code of practice for electrical installations
SS CP 10	Code of practice for the installation and servicing of electrical fire alarm systems
SS CP 13	Code of practice for mechanical ventilation and air-conditioning systems
SS CP 48	Code of practice for water services
SS 17	Specification for steel tubes suitable for screwing to BS 21 pipe threads
SS 142	Specification for steel pipes, fittings and specials for water, gas and sewerage
SS 332	Specification for fire doors

STANDARDS, PRODUCTIVITY AND INNOVATION BOARD (SPRING SINGAPORE)

The mission of the Standards, Productivity and Innovation Board, or SPRING Singapore in short, is to raise productivity so as to enhance Singapore's competitiveness and economic growth for a better quality of life for our people. In carrying out its mission, SPRING Singapore focuses on three areas: productivity and innovation, standards and quality, and small and medium-sized enterprises (SMEs) and the domestic sector.

Productivity and Innovation

The Productivity and Innovation focus has three key thrusts: promotion, organisational excellence and people excellence.

SPRING spearheads the Productivity Movement, which now encompasses innovation. A key strategy is the promotion of an innovation mindset among the workforce.

SPRING assists organisations to systematically achieve world-class standards of business excellence. At the apex of its internationally recognised Business Excellence programme is the Singapore Quality Award (SQA). Supporting programmes include those in the areas of innovation and service excellence.

SPRING initiates leading-edge programmes to enhance the capabilities of the workforce. This strategy supports the broader thrust of building up the competencies of organisations to achieve excellence.

Standards and Quality

The focus area of Standards and Quality has two major thrusts: standardisation and conformity assessment, and measurement infrastructure development. These are aimed at enhancing productivity, facilitating market access, ensuring safety and health, and protecting the environment.

SPRING administers the Singapore standardisation programme, which focuses on developing and promoting the use of standards in industry. It is also the national authority for the accreditation of conformity assessment bodies. SPRING enforces the Weights & Measures Act to protect consumers by ensuring that market transactions based on weights and measures are accurate. It also administers the Singapore Consumer Protection Registration Scheme to ensure that consumer electrical, electronic and gas appliances, and products are safe.

SPRING develops and maintains the measurement infrastructure to meet the measurement needs of industry. It provides a national system of traceability that covers measurements related to length, mass, time and frequency, electromagnetic, temperature, and radiometric and photometric quantities.

SMEs and Domestic Sector

The SMEs and Domestic Sector area of focus has three thrusts: broad-based assistance, enterprise upgrading and domestic sector development.

SPRING serves as the first stop for SMEs that need information and assistance for upgrading. As the secretariat to the Pro-Enterprise Panel, it actively seeks out suggestions on possible revisions to government rules and regulations to improve the business environment.

SPRING adopts a total approach in building up the capabilities of SMEs. This includes mentoring SMEs to map out strategic directions and implement best practices, and assisting fast-growing SMEs in areas such as business development and technology enhancement.

SPRING plays a lead role in creating a vibrant and resilient domestic sector. Examples of clusters in the sector are Retail, Construction, and Food and Beverage.

To support the development of SMEs and the Domestic Sector, SPRING administers the Local Enterprise Finance Scheme (LEFS) and the Local Enterprise Technical Assistance Scheme (LETAS). LEFS is a fixed interest rate loan for SMEs to expand and develop new capabilities. LETAS is a grant scheme to help SMEs seek external expertise to modernise and upgrade their operations.

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ABOUT THE NATIONAL STANDARDISATION PROGRAMME

Under the national standardisation programme, SPRING Singapore helps companies and industry to meet international standards and conformity requirements by creating awareness of the importance of standardisation to enhance competitiveness and improve productivity, co-ordinating the development and use of Singapore Standards and setting up an information infrastructure to educate companies and industry on the latest developments.

SPRING Singapore is vested with the authority to appoint a Standards Council to advise on the preparation, publication and promulgation of Singapore Standards and Technical References and their implementation.

Singapore Standards are in the form of specifications for materials and products, codes of practice, methods of test, nomenclature, services, etc. The respective standards committee will draw up the standards before seeking final approval from the Standards Council. To ensure adequate representation of all viewpoints in the preparation of Singapore Standards, all committees appointed consist of representatives from various interest groups which include government agencies, professional bodies, tertiary institutions and consumer, trade and manufacturing organisations.

Technical References are transition documents developed to help meet urgent industry demand for specifications or requirements on a particular product, process or service in an area where there is an absence of reference standards. Unlike Singapore Standards, they are issued for comments over a period of two years before assessment on their suitability for approval as Singapore Standards. All comments are considered when a technical reference is reviewed at the end of two years to determine the feasibility of its transition to a Singapore Standard. Technical References can therefore become Singapore Standards after two years, continue as Technical References for further comments or be withdrawn.

In the international arena, SPRING Singapore represents Singapore in the International Organisation of Standardisation (ISO), the Asia-Pacific Economic Co-operation (APEC) Sub-committee for Standards and Conformance (SCSC) and in the ASEAN Consultative Committee on Standards and Quality (ACCSQ). The Singapore National Committee of the International Electrotechnical Commission which is supported by SPRING Singapore, represents Singapore in the IEC.