Section one. General

0 Introduction

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

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

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

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

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

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

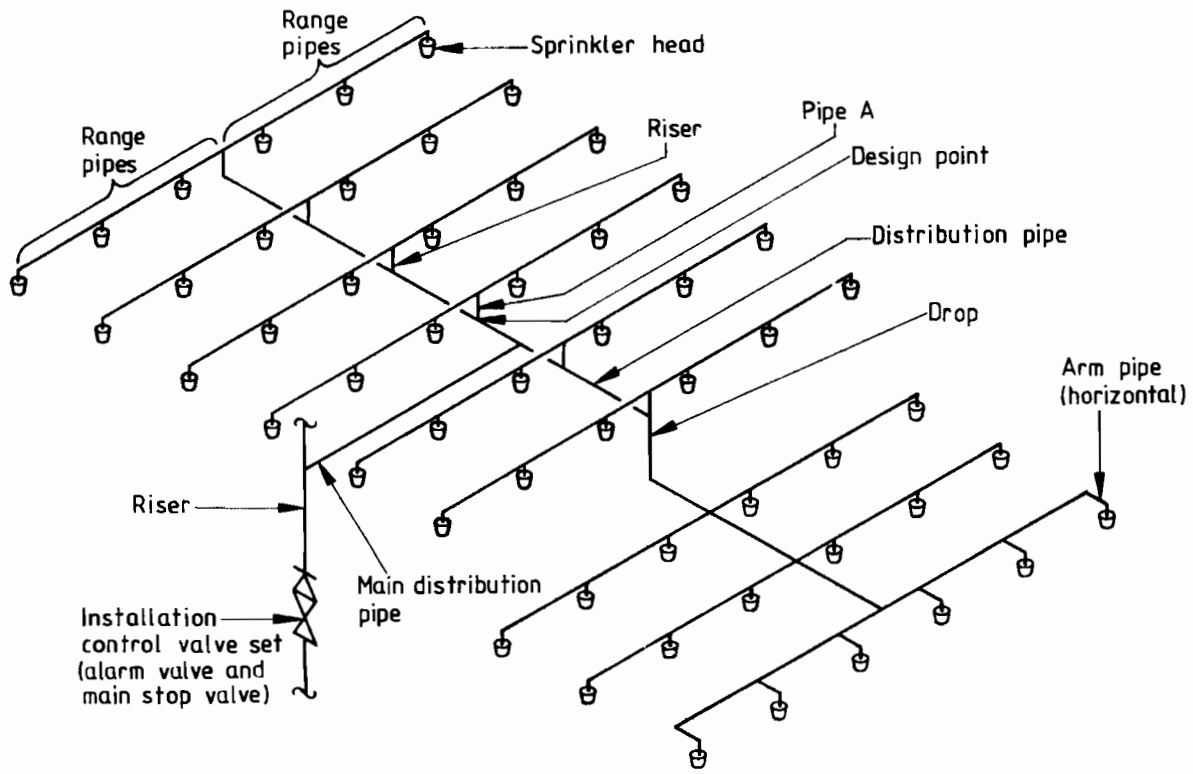
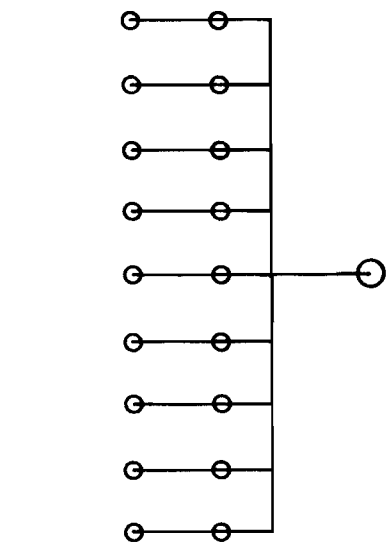
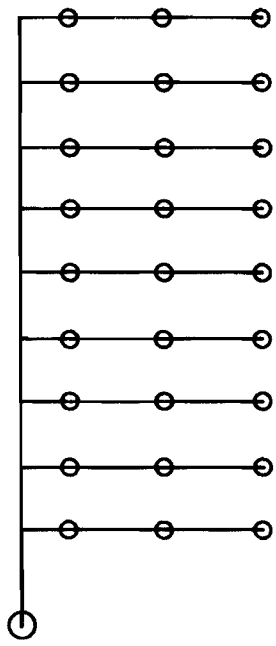


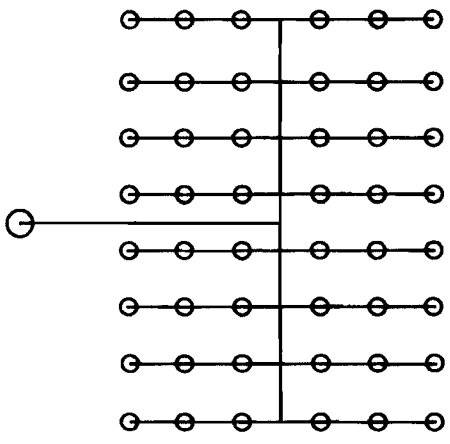
Figure 1. Main elements of a sprinkler installation



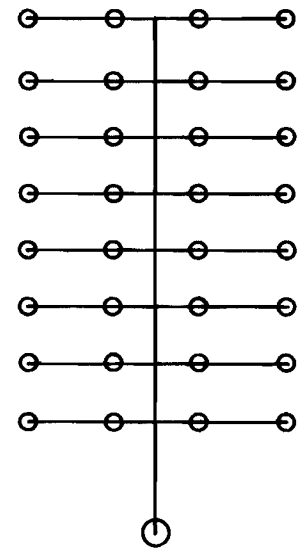
(a) Two end-side with central feed



(b) Three end-side with end feed



(c) Three end-centre with central feed



(d) Two end-centre with end feed

Figure 2. Examples of range pipe arrays

2.21 detector sprinkler. A sealed sprinkler mounted on a pressurized pipeline used to control a deluge valve. Operation of the detector sprinkler causes loss of air pressure to open the valve.

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

2.23 distribution pipe spur. A distribution pipe from a main distribution pipe, to a terminal branched pipe array (see figure 30).

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

2.25 drop. A vertical pipe feeding a distribution or range pipe.

2.26 end-centre array. A pipe array with range pipes on both sides of a distribution pipe (see figure 2).

2.27 end-side array. A pipe array with range pipes on one side only of a distribution pipe (see figure 2).

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

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

2.30 fire door. A door and frame of specified fire resistance complying with either:

(a) BS 476 : Part 8 : 1972; or

(b) BS 476 : Part 22 : 1987

with respect to integrity.

2.31 fire resistance. The ability of a component or the construction of a building to satisfy for a stated period of time the appropriate criteria specified in the relevant part of BS 476.

2.32 fire shutter. A shutter and frame of specified fire resistance complying with either:

(a) BS 476 : Part 8 : 1972; or

(b) BS 476 : Part 22 : 1987;

with respect to integrity.

2.33 (fully) hydraulically calculated. A term applied to pipework sized as specified in **18.1** (a) or an installation in which all the pipework downstream of the main installation control valve set is sized as specified in **18.1** (a).

2.34 gridded configuration pipe array. A pipe array in which water flows to each sprinkler by more than one route (see figure 37).

2.35 hanger. An assembly for suspending pipework from elements of building structure.

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

2.37 hydraulic alarm, intermittent. Sounding of an hydraulic water motor alarm gong for intervals totalling less than the alarm period.

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

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

2.40 installation, dry (pipe). An installation in which the pipework is charged with air under pressure.

2.41 installation, pre-action. Dry or alternate in dry mode, installation in which the alarm valve can be opened by an independent fire detection system in the protected area.

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

2.43 installation, wet (pipe). An installation in which the pipework is always charged with water.

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

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

2.46 looped configuration. A pipe array in which there is more than one distribution pipe route along which water may flow to a range pipe (see figure 36).

2.47 low-rise system. Sprinkler system in which the highest sprinkler is not more than 45 m above the lowest sprinkler or the sprinkler pumps whichever is the lower.

2.48 main distribution pipe. A pipe feeding a distribution pipe (see figure 1).

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

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

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

2.52 pipe array. The pipes feeding a group of sprinklers.

NOTE. Pipe arrays may be looped (see **2.46**), gridded (see **2.34**) or branched (see figure 35).

2.53 precalculated. A term applied to pipework sized as specified in **18.1** (b) or an installation in which pipes downstream of the design point are sized as specified in **18.1** (b).

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

2.55 riser. A vertical pipe feeding a distribution or range pipe above.

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

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

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

2.59 sprayer. A sprinkler that gives a downward conical pattern discharge.

2.60 sprayer, high velocity. An open nozzle used to extinguish fires of high flashpoint liquids.

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

2.62 sprinkler, (automatic). A temperature-sensitive sealing device which opens to discharge water for fire extinguishing.

NOTE. The term 'automatic sprinkler' is now rarely used. The term 'sprinkler' does not include 'open sprinkler' (see 2.72).

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

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

2.65 sprinkler, conventional pattern. A sprinkler that gives a spherical pattern of water discharge.

See also:

cut-off sprinkler (**2.16**);
detector sprinkler (**2.21**).

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

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

2.68 sprinkler, fusible link. A sprinkler which opens when a component provided for the purpose melts.

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

2.70 sprinkler, horizontal. A sprinkler in which the nozzle directs water horizontally.

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

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

2.73 sprinkler, pendent. A sprinkler in which the nozzle directs water downwards.

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

2.75 sprinkler, roof or ceiling. A sprinkler protecting the roof or ceiling.

2.76 sprinkler, sidewall pattern. A sprinkler that gives an outward half-paraboloid discharge.

2.77 sprinkler, spray pattern. A sprinkler that gives a downward paraboloid pattern discharge.

2.78 sprinkler, upright. A sprinkler in which the nozzle directs water upwards.

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

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

2.81 staggered (sprinkler) layout. An off-set layout with the sprinklers displaced one-half pitch along the range pipe relative to the next range or ranges (see figure 38(b)).

2.82 standard (sprinkler) layout. A rectilinear layout with the sprinklers aligned perpendicular to the run of the ranges (see figure 38(a)).

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

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

NOTE. The LPC publishes a list of components suitable for use in sprinkler systems.

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

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

2.87 tail-end alternate (wet and dry pipe) extension. A part of a wet installation that is selectively charged with water or air according to ambient temperature conditions.

2.88 tail-end dry extension. A part of a wet or alternate installation that is charged permanently with air under pressure.

2.89 terminal main configuration. A pipe array with only one water supply route to each range pipe.

2.90 terminal range configuration. A pipe array with only one water supply route from a distribution pipe.

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

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

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

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

(g) staircases, washrooms, toilets and WCs external or internal to the sprinkler-protected building which form a means of communication between the sprinklered building and a non-sprinklered building. In any such part not provided with sprinkler protection all openings into the communicating area from the sprinklered and from the non-sprinklered building shall be protected by fire doors of not less than 1 h fire resistance.

4.2.2.3 *Life safety systems.* Sprinkler protection shall be considered for, but need not be provided in, the following.

(a) In general, rooms adjacent to areas where a life safety sprinkler system is required by an authority solely to maintain safe conditions for the evacuation of persons from the sprinkler-protected areas. Any part not provided with sprinkler protection shall be enclosed by walls, ceilings and floors with a fire resistance of not less than 1 h in which any openings are fitted with cut-off sprinklers on the non-sprinklered side and either with a fire door or fire shutter with a fire resistance of not less than 30 min.

(b) Auditoria in theatres with separated stages (i.e. where there is a safety curtain between the stage and auditorium) where a life safety sprinkler system is required as a licensing condition by an authority solely to maintain safe conditions for the evacuation of persons from the theatre. Where sprinkler protection is not provided in the auditorium the safety curtain shall be provided with a line of drenchers controlled by a quick opening valve (e.g. a plug valve) fitted in an accessible position. The water supply for the drenchers shall not be taken downstream of any sprinkler installation valve set.

COMMENTARY AND RECOMMENDATIONS ON 4.2.2.3.
In theatres with a separated stage it may be necessary, in order to satisfy the requirements of some licensing authorities, to provide sprinklers throughout the stage and associated areas including workshops, dressing rooms, scenery and other storerooms but not in the auditorium, etc. The licensing authorities will normally require drenchers to be fitted as specified here.

Subject to the requirements of the authorities it is recommended that life safety sprinkler systems be extended to all areas except those specified in 4.2.1, 4.2.2.1 and 4.2.2.2.

5 Classification of occupancies and fire hazards

5.1 General

Occupancies or parts thereof shall be classified as:

light hazard; or
ordinary hazard; or
high hazard.

Ordinary- and high-hazard occupancies shall in addition be assessed for any special variation to normal requirements specified in **5.5**.

In storage areas the goods including any packaging shall be categorized as category I, II, III or IV (see tables 1 and 2).

COMMENTARY AND RECOMMENDATIONS ON 5.1. *Hazard classification provides the basis for the design of sprinkler systems and is a skilled operation which is best carried out by the authorities (see 2.13). The range of occupancies and hazards encountered is extremely large, and it may be necessary to classify a particular case by analogy. The classification affects the choice of installation, operational method, water supply arrangements, components, pipework design etc.*

Although this specification deals mainly with sprinkler systems which are installed primarily to reduce loss of property in fire, some sprinkler systems are installed which additionally may serve for the protection of life. In particular circumstances these may form an integral part of measures approved by the fire authority for the protection of life, for example in covered and enclosed shopping complexes, where automatic sprinkler systems serve to prevent the spread of fire and its products to adjacent exit routes (see BS 5588 : Part 10).*

Where a system is a high-rise system or a life safety system, additional safeguards are considered necessary to ensure reliability although the hazard is classified in the normal manner. These are detailed under the heading 'Life safety' in the appropriate sections.

Figure 3 shows the relationship between classes and may be used in the process of classification.

5.2 Light hazard

In non-industrial occupancies where the quantity and combustibility of the contents are low, rooms and corridors not more than 126 m^2 in area and bounded by elements of construction with a fire resistance of not less than 30 min shall be classified as light hazard.

COMMENTARY AND RECOMMENDATIONS ON 5.2. *Typical light-hazard occupancies are given in figure 3. No room may have more than six sprinklers (see 14.2).*

Rooms larger than 126 m^2 *or with walls of lower fire resistance are classified as ordinary hazard, group I.*

5.3 Ordinary hazard

5.3.1 In non-industrial occupancies, rooms which exceed the limits specified in **5.2** for light-hazard classification shall be classified as ordinary hazard, group I.

5.3.2 Commercial and industrial occupancies involving the handling, processing and storage of mainly ordinary combustible materials, which are unlikely to develop intensely burning fires in the initial stages, shall be classified as:

ordinary hazard, group I; or
ordinary hazard, group II; or
ordinary hazard, group III; or
ordinary hazard, group IIIS (group III special).

COMMENTARY AND RECOMMENDATIONS ON 5.3. *Table 2 gives examples of goods categories.*

Examples of the four ordinary-hazard occupancy groups are given in table 3.

*In preparation.

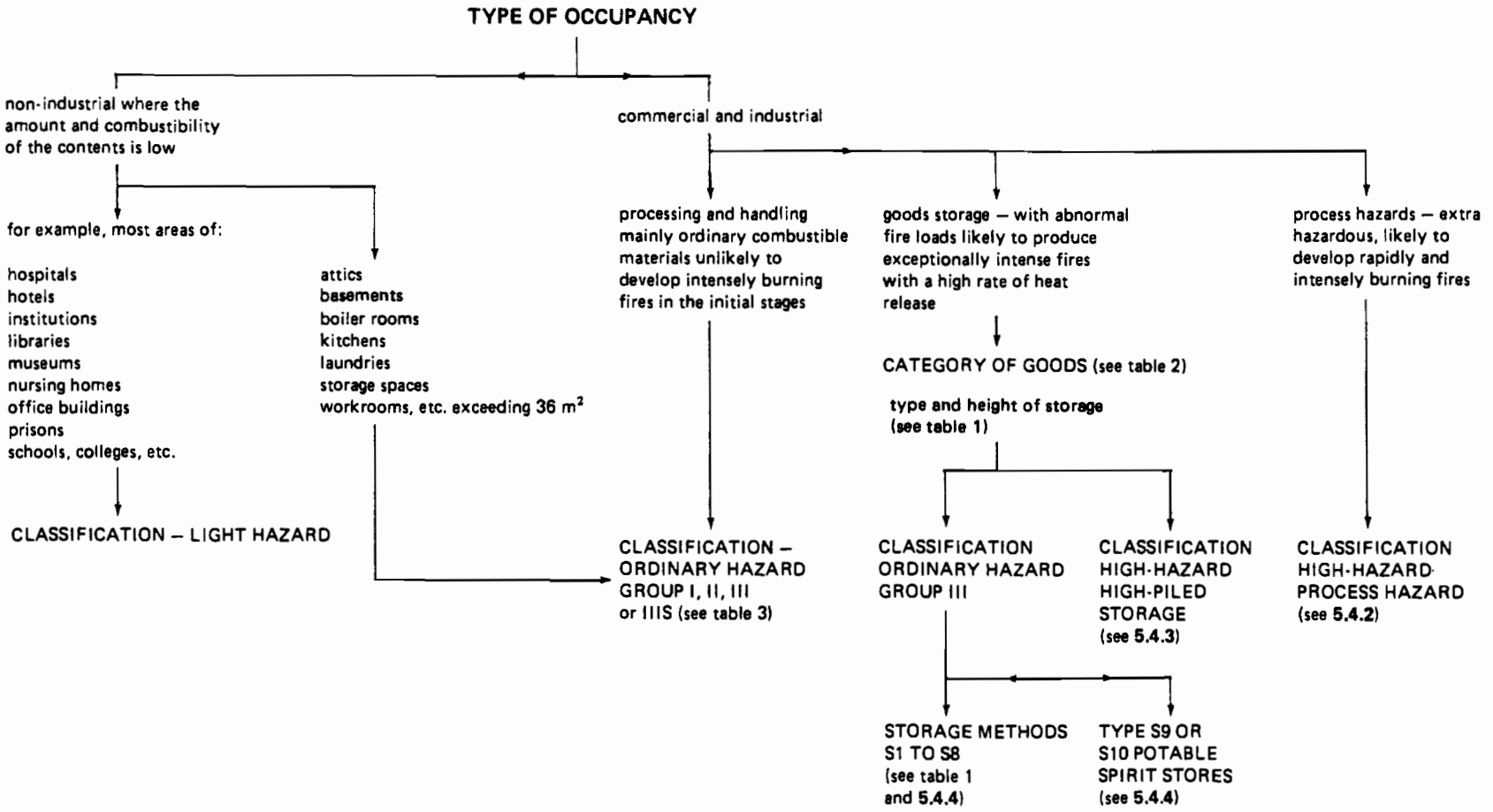


Figure 3. Hazard classification flow chart

Table 3. Typical examples of ordinary-hazard occupancies

Type of business	Ordinary-hazard group			
	I	II*	III†	IIIS
Ceramics	abrasive wheel and powder factories	potteries	glass factories	
Chemicals	cement works	chemical works (ordinary)	soap and candle factories	match factories
Engineering	jewellery factories	engineering works including light metal works	aircraft factories excluding hangars, radio and television and electronic equipment factories, motor vehicle manufacturing and assembly plants	
Food and beverages	abattoirs, breweries (excluding bottling sections, maltings and cooperages) creameries and wholesale dairies	bakeries and biscuit factories, brewery bottling sections, brewery maltings and cooparages of non-combustible construction, confectionery factories, sauce, pickle and preserved foods factories	corn, flour and provender mills, sugar refinaries	distilleries (still houses), oil mills (except areas where flammable solvents are stored)
Miscellaneous	restaurants and cafes		laundries, motor garages broadcasting studios and transmitting stations, brush factories, tanneries car parks (above or below ground)	theatres, film and television studios
Paper			paper mills and paper goods factories, printing (and allied trades) works, wallcovering factories	
Rubber and plastics			plastics and plastics goods (excluding foamed plastics) factories, rubber and rubber goods factories (excluding foamed rubber), wallcovering factories	
Shops and offices	Offices (not high-rise) not meeting the requirements of 5.2 for light hazard		departmental stores and retail shops	
Textiles and clothing			bleach, dye and print works, boot and shoe manufacturers, carpet factories, clothing factories, cotton mills (excluding preparatory processes), flax, jute and hemp mills (excluding preparatory processes), hosiery and lace factories, shirt factories, woollen and worsted mills	cotton mills, (processes preparatory to spinning) flax, jut and hemp mills, (processes preparatory to spinning), flax and hemp scutch mills
Timber and wood			Saw mills, woodworking and furniture (without foam upholstery) factories	

*Where there is painting or such other areas of high fire load treat as group III.

†Warehouses generally, multi-storey and high-rise buildings to ensure flexibility.

5.5 Sprinkler installation variations

Special consideration shall be given to ordinary- and high-hazard occupancies where variations of the generally applicable requirements are specified.

COMMENTARY AND RECOMMENDATIONS ON 5.5. *Variations are specified for the following:*

(a) hazardous processes and explosion hazards (see 6.1.2, 12.5, 20.1.2.1 and 21.2.2.4);

(b) bleach, dye and textile print works, paper mills (see also item (h) below), tanneries, premises or parts of premises where corrosive conditions exist (see 21.2.1.3, 22.1.2, 25.11 and 35.2.3);

(c) alkali plants, electroplating and galvanizing works, foundries, organic fertilizer plants, pickle and vinegar works (see 25.11 and 35.2.3);

(d) cold-storage warehouses (see 6.5.1.2, 6.5.3.3, 20.3.4, clause 23, 25.8, 26.6.4, table 70 and 27.2);

(e) computer areas (see 6.1.2, 10.1.2, 20.1.4, 26.9.3 and 27.4.6);

(f) corn, rice, provender and oil mills (see table 70 and 26.7.2);

(g) film and television production studios (see table 70 and 26.9.1);

(h) papermaking machines (see 20.1.4 and 26.8.4);

(i) theatres and auditoria (see 4.2.2.3, 26.9.2 and table 70);

(j) drying ovens and enclosed paint lines (see 25.7.4 and 26.7.7);

(k) high-rise buildings (see 6.3.2, 6.3.4, 12.3, 13.2, 15.2.2.2, 17.3.2, 17.4.6.1, 17.4.6.3, 20.1.4, 20.3.1, 24.2.3.2, 27.1.1, 27.2.3, table 3 and table 28).

6 Selection of installation type, size and design

6.1 General

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

6.1.2 *Size of an installation.* In addition to the size limits appropriate to types given in this clause an installation shall not cover more than the following:

(a) if protecting an explosion hazard, the containment area of the hazard; or

(b) if protecting a computer area, the computer area except where the installation includes a zone covering only the computer area.

6.2 Types

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

(a) wet pipe;

(b) alternate (wet and dry pipe);

(c) dry pipe;

(d) pre-action;

(e) recycling.

COMMENTARY AND RECOMMENDATIONS ON 6.2. *Installations based on (a) and/or (b) of 6.2 may also include extensions of the following additional types:*

(a) tail-end alternate;

(b) tail-end dry pipe;

(c) deluge.

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

Where freezing or elevated temperatures are experienced either frequently or continuously a dry pipe installation should be installed, or only in small areas tail-end dry pipe extensions should be installed as extensions to the main installation. See 6.3 to 6.9 for the limits on size of the various types of installation.

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

6.3 Wet pipe installations

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

COMMENTARY AND RECOMMENDATIONS ON 6.3.1. *Where non-freezing conditions cannot be ensured throughout the premises, unheated areas may be protected by a tail-end alternate wet and dry pipe system subject to the limits on number of sprinklers concerned given in 6.6, or by the use of dry upright or dry pendent sprinklers projecting into the low-temperature area or less preferably by the use of trace heating and lagging of the pipework. BS 6351 : Part 3 gives recommendations for trace heating. BS 5422 and BS 5970 give recommendations for lagging.*

6.3.2 *Size of installations, sections and zones.* The number of sprinklers in an installation, section or zone (including tail-end extensions (see **6.6**) but not including sprinklers in concealed spaces or in machines etc.) shall not exceed the following.

(a) Light hazard:	500 per installation.
(b) Ordinary hazard:	
(1) In single-storey buildings, or unheated service areas and car parks near or below ground level in multi-storey buildings, ordinary and/or high hazard inclusive of any light-hazard sprinklers on the same installation main control valve set:	1000 per installation.

(2) In multi-storey buildings, and for high-rise systems, excluding unheated service areas and car parks near or below ground level:	500 per zone, or if an installation is not divided into zones, 1000 per installation.
(c) High hazard:	1000 per installation.
(d) Installations with intermediate level sprinklers	
(1) Installations with only intermediate level sprinklers (i.e. fed from a set of installation control valves separate from the roof or ceiling sprinkler distribution pipework):	1000 per installation
(2) Installations with ceiling and intermediate level sprinklers:	1000 per installation of which not more than 50 shall be intermediate level protection.
(e) In a life safety system:	200 per zone or, for an installation not divided into zones, 200 per installation.

6.3.3 *Life safety*

6.3.3.1 Sprinkler installations for life safety shall be of the wet pipe type and any tail-end extension shall comply with **6.6**.

6.3.3.2 Sprinkler installations shall, if necessary, be arranged in zones; no unzoned installation or zone shall:

(a) cover an area under more than one ownership;

(b) cover more than one floor level, but this level may include additionally a mezzanine floor not exceeding 100 m^2 in area.

COMMENTARY AND RECOMMENDATIONS ON 6.3.3.2.
6.3.2(e) restricts the size of zones to 200 sprinklers.

6.3.4 *High-rise buildings.* The height difference between the lowest and highest sprinklers in an installation shall be not more than 45 m. The distribution pipes shall be independently connected to the main rise pipe at the floor they serve. No section shall extend to more than one floor and each section shall be served by a separate main rise pipe.

6.4 Alternate (wet and dry pipe) installations

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

COMMENTARY AND RECOMMENDATIONS ON 6.4.1.
Alternate installations are not recommended for the protection of high-hazard storage.

Areas where freezing conditions may be experienced at times when the installation is in the wet mode may be protected by a tail-end dry or alternate system, or with dry upright or dry pendent sprinklers projecting into the low-temperature area.

6.4.2 *Mode of operation.* Alternate installations shall be operated in the wet mode only when there is no danger of water in the pipes freezing. In the dry mode the installation shall be pressurized with air to within the pressure range recommended by the alarm valve manufacturer.

6.4.3 *Size of installation*

6.4.3.1 The number of sprinklers, including any in tail-end extensions, shall not exceed the following.

(a) In a light-hazard installation with accelerator or exhauster:	250 per installation.
(b) In a light-hazard installation without accelerator or exhauster:	125 per installation.
(c) In an ordinary- and/or high-hazard installation with accelerator or exhauster:	500 per installation.
(d) In an ordinary- and/or high-hazard installation without accelerator or exhauster:	250 per installation.

6.4.3.2 The notional number of sprinklers, including any in tail-end extensions, shall not exceed the following.

(a) In a combined light- and ordinary-hazard installation:	500 per installation.
(b) In a combined light- and high-hazard installation:	250 per installation.

The notional number shall be calculated as the actual number of ordinary- and/or high-hazard sprinklers plus twice the actual number of light-hazard sprinklers in the installation.

6.4.4 *Sprinkler types.* The installation shall be fitted with upright sprinklers, or dry pendent sprinklers.

6.5 Dry pipe installations

6.5.1 *General*

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

COMMENTARY AND RECOMMENDATIONS ON 6.5.1.
For example, wet pipe and alternate installations cannot be used in buildings where the temperature is artificially maintained close to or below 0 °C, such as in cold stores, fur vaults, etc., or where the temperature is maintained or may be raised above 70 °C such as in drying ovens, etc., and where the pipework cannot be run outside the cold or hot areas.

6.5.1.2 In cold-storage warehouses refrigerated by air circulation, automatic means shall be provided to automatically shut down the air circulation fans when the sprinkler system operates.

6.5.2 *Charging pressure.* The installation shall be pressurized with air to within the pressure range recommended by the alarm valve manufacturer.

COMMENTARY AND RECOMMENDATIONS ON 6.5.2. *A higher pressure may cause undesirable delay in water discharge.*

6.5.3 *Size of installation*

6.5.3.1 The number of sprinklers shall not exceed the following.

(a) In a light-hazard installation with accelerator or exhauster:	250 per installation.
(b) In a light-hazard installation without accelerator or exhauster:	125 per installation.
(c) In an ordinary- and/or high-hazard installation with accelerator or exhauster:	500 per installation.
(d) In an ordinary- and/or high-hazard installation without accelerator or exhauster:	250 per installation.

6.5.3.2 The notional number of sprinklers (including any in tail-end extensions) shall not exceed the following.

(a) In a combined light- and ordinary-hazard installation:	500 per installation.
(b) In a combined light- and high-hazard installation:	250 per installation.

The notional number shall be calculated as the actual number of ordinary- and/or high-hazard sprinklers plus twice the actual number of light-hazard sprinklers in the installation.

6.5.3.3 In cold-storage warehouses with air circulation refrigeration where:

(a) the pipework is within the cold chamber; and

(b) the number of sprinklers excluding any sprinklers above a false ceiling exceeds 50;

each installation shall comprise two, three, four or five tail-end extensions each containing not more than 50 sprinklers plus any sprinklers in the plenum fed directly from the pipework below.

6.5.4 *Sprinkler types.* The installation shall be fitted with:

(a) upright sprinklers; or

(b) dry pendent sprinklers; or

(c) in cold-storage warehouses where the pipework is in the cold chamber, pendent sprinklers.

6.6 Tail-end alternate pipe and tail-end dry pipe extensions

6.6.1 *General*

6.6.1.1 Tail-end alternate extensions shall be installed only in comparatively small areas where there is a possible frost danger in an otherwise adequately heated building as extensions to wet pipe installations. They shall comply with the appropriate requirements of **6.4**.

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

(a) extensions to wet or alternate installations in high-temperature ovens or stoves; or

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

They shall comply with the appropriate requirements of **6.5**.

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

6.7 Pre-action installations

6.7.1 *General.* There are two types of pre-action installation as follows:

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

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

COMMENTARY AND RECOMMENDATIONS ON 6.7.1. *Type 1 installations are appropriate to hazards where the cost or inconvenience of water damage may be exceptionally high. Because the sprinkler installation control valve opens only as a result of operation of the fire detection system much reservation should be exercized when considering the use of Type 1 installations. Where a pre-action installation is to be used for high hazard Type 2 should preferably be used. The fire detectors may be expected to signal the presence of fire at a early stage (before operation of any sprinkler) so that hand or manually operated appliances may well be successfully used to prevent sprinkler water discharge.*

Type 2 installations are appropriate to large alternate dry pipe sprinkler installations where rapidly developing intense fires may occur. The possible early detection of a fire by fire detectors will prime the sprinkler installation with water, so that discharge will not be delayed when a sprinkler or sprinklers operate. Failure of the fire detector system does not prevent normal operation of the sprinkler installation.

For high-hazard occupancies Type 2 is preferable to Type 1.

Because they are more complicated, pre-action installations should be used only where a wet, dry or alternate system would be unsuitable. The detection system should be installed as recommended in BS 5839 : Part 1.

6.7.2 *Mode of operation*

6.7.2.1 The sprinkler installation pipework shall be normally charged with air under pressure, and monitored to give a warning indication on reduction of the air pressure. Complete loss of air pressure shall initiate the visual and audible indications for a fire alarm (see clause **27**).

6.7.2.2 The fire detection system shall automatically give an alarm on operation and shall operate a continuously energized valve or other trip mechanism, suitable for sprinkler service, to release (Type 1) or prime (Type 2) the pre-action alarm valve when the valve or trip mechanism becomes de-energized.

6.7.3 *Sprinkler head orientation.* In type 1 installations, sprinklers shall be installed in the upright position or only in a building free from the danger of freezing, in the upright or pendent position. In type 2 installations, sprinklers shall be installed in the upright position.

6.7.4 *Size of pre-action installations.* The number of sprinklers shall not exceed the following.

(a) In a light-hazard installation:	500 per installation.
(b) In an ordinary-hazard installation:	1000 per installation.
(c) In a high-hazard installation:	1000 per installation.

6.8 Recycling installations

6.8.1 *General.* Recycling installations shall only be installed where it is necessary for the following reasons:

(a) to restrict water damage after a fire is extinguished;

(b) to avoid closure of the main installation stop valve if modifications are made to the installation pipework or if sprinkler heads are to be replaced;

(c) to prevent water damage caused by accidental mechanical damage of the installation pipework or sprinklers.

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

COMMENTARY AND RECOMMENDATIONS ON 6.8.1. *Heat detectors used in this application may be exposed to flame during the course of the on/off cycling process, and it is therefore essential that the operating temperature characteristics do not change during the course of a fire incident.*

The requirements detailed in (b) above may only be met if a safe working practice can be devised to meet the contingency that the installation may operate while work is in progress (see 7.4). Full details of the practice should be provided at the planning stage.

6.8.2 *Mode of operation*

6.8.2.1 Water discharge cycling shall be controlled by heat detectors installed at the roof or ceiling which operate as an electrical interlock causing a water flow control valve to open and close. A timer shall be provided to delay closure of the flow control valve for a predetermined period in each cycle after lowering of the temperature of the heat detectors.

COMMENTARY AND RECOMMENDATIONS ON 6.8.2.1. *A* 5-min *delay is recommended.*

6.8.2.2 The flow control valve, monitoring devices, and the electrical interlock system shall be suitable for sprinkler use.

COMMENTARY AND RECOMMENDATIONS ON 6.8.2.2. *Closure of the flow control valve during the automatic cycling sequence should not cause excessive water hammer.*

6.8.2.3 Heat detectors to operate the installation flow control valve cycling sequence shall be provided at the roof or ceiling as specified in BS 5839 : Part 1.

6.8.3 *Sprinkler head orientation.* Where there is a danger of freezing, sprinklers shall be installed in the upright direction.

COMMENTARY AND RECOMMENDATIONS ON 6.8.3. *Where there is no danger of freezing, sprinklers may be installed in the upright or pendent position.*

6.8.4 *Size of recycling installations.* The number of sprinklers shall not exceed 1000 per installation.

6.9 Deluge installations

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

6.9.2 *Mode of operation.* The installation shall be provided with the following:

(a) a manual release; and/or

(b) an automatic release, which shall be either:

(1) a multiple control or controls; or

(2) a deluge valve;

to initiate discharge.

COMMENTARY AND RECOMMENDATIONS ON 6.9.2. *A manual release should only be provided where a process is continuously supervised by personnel, and where the disruption caused by unwanted discharge may be excessive. Installations without an automatic release should be used for small area protection only.*

A multiple control should only be used for small areas of hazard. The area is limited because fire detection is possible only at the multiple control, and also by the water-carrying capacity of the multiple control. The number of detection points may be increased by the use of two or more controls delivering water into a ring pipework arrangement feeding all of the open sprayers in the installation.

6.9.3 *Pipework.* Pipework shall be fully hydraulically calculated (see clause **18** and **24.3**).

The installation pipework shall drain automatically after operation, by means not involving excessive loss of water during normal operation.

COMMENTARY AND RECOMMENDATIONS ON 6.9.3. *Design densities and AMAOs for process hazards are specified in 14.4.1. Design densities and AMAOs for oil and flammable liquid hazards are not given in this specification.*

8.3.3.2 *Precalculated pipework.* For precalculated pipework the following details shall be given on, or with, the drawings:

(a) identification of the design point of each array on the layout drawing (for example, as in figure 29);

(b) a summary of the pressure losses between the control valve and the design points at the following design rates of flow.

(1) In a light-hazard installation: 225 L/min.

(2) In an ordinary-hazard installation: 1000 L/min.

(3) In a high-hazard installation: the flow corresponding to the appropriate design density given in tables 16, 17, 18 or 19.

The calculation as specified in **24.2**, showing that:

(i) in light- and ordinary-hazard installations, for each run of distribution pipework

$$P_f - P_h$$

is not more than the appropriate value specified in **24.2**; and/or

(ii) In high-hazard installations designed using tables 60 or 61

$$P_f + P_d + P_s$$

is not more than the residual pressure available at the control valves from the water supply when it is tested at the appropriate flow rate

where

P_d is the pressure at the design point specified in tables 16, 17, 18 or 19 as appropriate;

P_f is the frictional pressure loss in the distribution pipework between the design point and the control valve 'C' gauge;

P_h is the static pressure between the level of the highest design point on the floor concerned and the level of the highest design point in the top storey; and

P_s is the static head loss owing to the height of the highest sprinkler in the array concerned above the control valve 'C' gauge.

COMMENTARY AND RECOMMENDATIONS ON 8.3.3.2.

A typical summary is shown in figure 4. The relevant layout drawing should also be supplied.

For light- and ordinary-hazard installations with precalculated pipework the pressure needed at the design point is not stated. Instead the friction loss in the pipework between the control valve and the design points is limited to a predetermined quantity, incorporated in the value specified for pressure at the control valves in section four. Static head is added to this pressure to give the value defining the minimum actual water supply running pressure.

8.3.3.3 *Hydraulically calculated pipework.* For hydraulically calculated pipework (see **24.3**), the following shall be given, with detailed calculations, either on purpose-designed work sheets or as a computer print-out:

(a) *for each design area of operation:*

(1) the area identification;

(2) the hazard class;

(3) the specified density of discharge (in mm/min);

(4) the assumed area of maximum operation (AMAO) (in m^2);

(5) the number of sprinklers in the AMAO;

(6) the sprinkler nominal orifice size (in mm);

(7) the maximum area covered per sprinkler (in m^2);

(8) detailed and dimensioned working drawings showing the following:

(i) the node or pipe reference scheme used to identify pipes, junctions, sprinkler heads and fittings which need hydraulic consideration;

(ii) the position of the hydraulically most unfavourable AMAO;

(iii) the position of the hydraulically most favourable AMAO;

(iv) the four sprinklers upon which the design density is based (see **24.3.4**);

(v) the height above datum of each point of identified pressure value.

(b) *for each operating sprinkler:*

(1) the sprinkler node or reference number;

(2) the sprinkler nominal *k* factor;

(3) the flow through the sprinkler (in L/min);

(4) the inlet pressure to the sprinkler or sprinkler assembly (in bar);

(c) *for each hydraulically significant pipe:*

(1) the pipe node or other reference;

(2) the pipe nominal bore (in mm);

(3) the Hazen-Williams constant, C, or the *k* factor, for the pipe (see table 36);

(4) the flow through pipe (in L/min);

(5) the nominal fluid velocity (in m/s);

(6) the length of pipe (in m);

(7) the numbers, types and equivalent lengths of fittings;

(8) the static head change in pipe (in m);

(9) the pressures at inlet and outlet of pipe (in bar);

(10) the friction loss in pipe (in bar);

(11) the indication of flow direction.

Statement of distribution pipe losses between the various design points and the installation valves

HAZARD GROUP: ORDINARY HAZARD DESIGN FLOW RATE: 1000 L/min.

NAME & ADDRESS: A.B. CEE COMPANY, DEE LANE, ENDING

1	2	3	4	5	6	7		
Run of distribution pipe from valves to (letter)	*Pipe size*	*Pipe length*	*No. of turns*	*Equiv. pipe length of turns*	*Total equiv. length of pipe*	*Pressure loss at design flow rate*		
						Pipe losses	*Static head gain (Ph)*	*Difference*
	mm	m		m	m	mbar	mbar	mbar
A-FLOOR 3	65	3.5	–	–	3.5	122		
	80	7	–	–	7	111		
	100	49	2	6	55	240		
						473		
							0	
								473
B-FLOOR 3	65	7	–	–	7	243		
	80	1.9	–	–	1.9	30		
	100	20	1	3	23	101		
						374		
							0	
								374
C-FLOOR 2	65	10.5	–	–	10.5	365		
	80	16.9	–	–	16.9	268		
	100	28.3	2	6	34.3	150		
						783		
							380	
								403
D-FLOOR 2	65	8.8	–	–	8.8	306		
	80	–	–	–	–	0		
	100	16.3	1	3	19.3	84		
						390		
							380	
								10
E-FLOOR 1	65	10.5	–	–	10.5	365		
	80	38.9	2	6	44.9	712		
	100	2.5	–	–	2.5	11		
						1088		
							760	
								328
F-FLOOR 1	65	8.9	–	–	8.9	309		
	80	9.9	1	3	12.9	205		
	100	2.5	–	–	2.5	11		
						525		
							760	
IN ALL SECTIONS THE PRESSURE LOSS IN THE DISTRIBUTION PIPE IS LESS THAN 500 mbar								-235

NOTE. The pressure drop caused by any orifice plate in the distribution pipework should be taken into account by a corresponding reduction of the static head gain.

Figure 4. Typical statement of pressure loss calculations

COMMENTARY AND RECOMMENDATIONS ON 8.3.3.3. *A line diagram of the pipe layout should be prepared showing the following:*

(i) the node or pipe reference numbers;

(ii) the distribution pipes;

(iii) the range pipes;

(iv) the sprinkler heads under consideration;

(v) the four hydraulically most unfavourably placed heads (see 24.3);

(vi) the flow through, and pressure at the end of, each hydraulically significant pipe.

8.3.4 *Water supply*

8.3.4.1 *Water supply drawings.* The drawings shall show water supplies and pipework therefrom up to the installation control valves. The drawings shall be on an indicated scale of not less than 1:100. A key to the symbols shall be included. The position and type of stop and check valves and any pressure reducing valve, water meter, water lock, orifice plate and any connection supplying water for other services (see **12.3**), shall be indicated.

8.3.4.2 *Hydraulic calculation.* An hydraulic calculation (with relevant flow tests) shall show that each trunk main together with any branch main, from each water supply to a main installation control valve set water supply test and drain valve and control valve 'C' gauge (i.e. including the installation control valves) is capable of providing the required pressure and flow at the installation control valve test and drain valve.

8.3.4.3 *Town main.* Where a town main forms one or both of the supplies or provides infill to a suction tank type C (see **17.1.4**) the following details shall be given:

(a) the nominal diameter of the main;

(b) whether the main is double-end fed or dead-end; if dead-end, the location of the nearest double-end fed main connected to it;

(c) the pressure-flow characteristic graph of the town main determined by test at a period of peak demand. The graph shall be corrected for friction losses and static head difference between the test location and either the control valve 'C' gauge or the suction tank infill valve, as appropriate,

(d) the date and time of the town main test;

(e) the location of the town main test point relative to the installation control valve.

Where the pipework is fully hydraulically calculated the following additional details shall be given:

(f) a modified pressure-flow characteristic graph (see **8.3.4.3**(c)) indicating the usable pressure at any flow up to the maximum installation demand;

(g) the demand pressure-flow characteristic graph for each installation for the hydraulically most unfavourable (and if required the most favourable) AMAO with pressure taken as at the control valve 'C' pressure gauge.

8.3.4.4 *Automatic pump set.* Where automatic pump sets form one or more of the water supplies a pump characteristic curve for low water level 'X' (see figure 23) shall be provided. The curve shall show the estimated performance of the pump or pumps under installed conditions at the control valve 'C' gauge.

In addition where the pipework is fully hydraulically calculated the following details of the automatic pump set shall be provided:

(a) the pump manufacturer's data sheet showing the following:

(1) the generated head graph;

(2) the power absorption graph;

(3) the net positive suction head (NPSH) graph;

(4) a statement of the power output of each prime mover.

(b) the installers' data sheet showing the pump set installed performance pressure-flow characteristics, at the control valve 'C' gauge for normal water level and for low water level 'X' (see figure 23), and at the pump outlet pressure gauge for normal water level;

(c) the height difference between the control valve 'C' gauge and the pump delivery pressure gauge;

(d) the installation number and the hazard classification(s);

(e) the demand pressure-flow characteristic for the hydraulically most unfavourable and most favourable AMAO, calculated at the control valve 'C' gauge as specified in clause **24**;

(f) the available and the specified NPSH at maximum predicted flow ($Q_{max.}$; see figure 20).

COMMENTARY AND RECOMMENDATIONS ON 8.3.4.4. *Typical examples of pump manufacturer's data sheets are shown in figure 5. Figure 20 is an illustration of an installer's data sheet.*

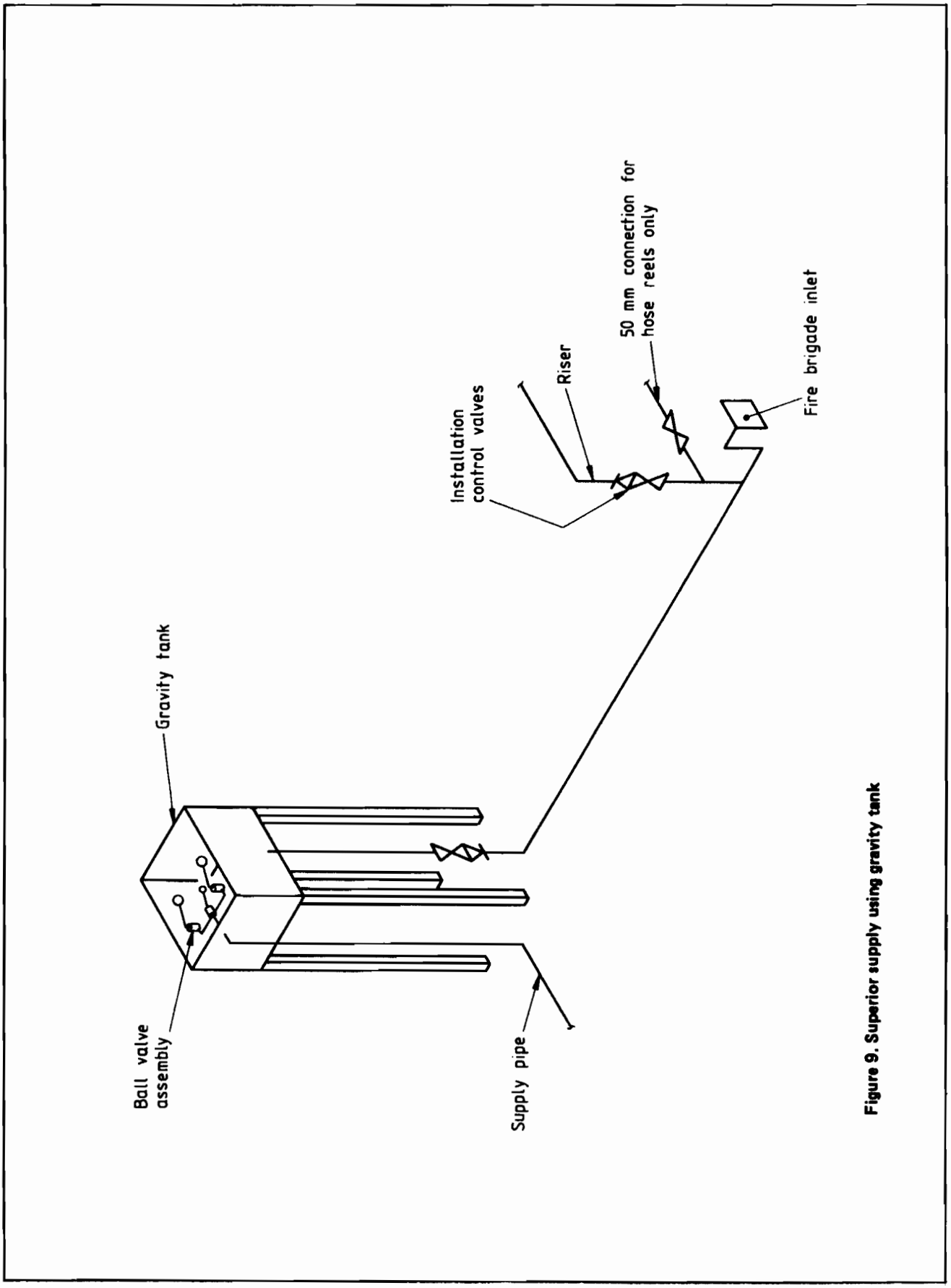


Figure 9. Superior supply using gravity tank

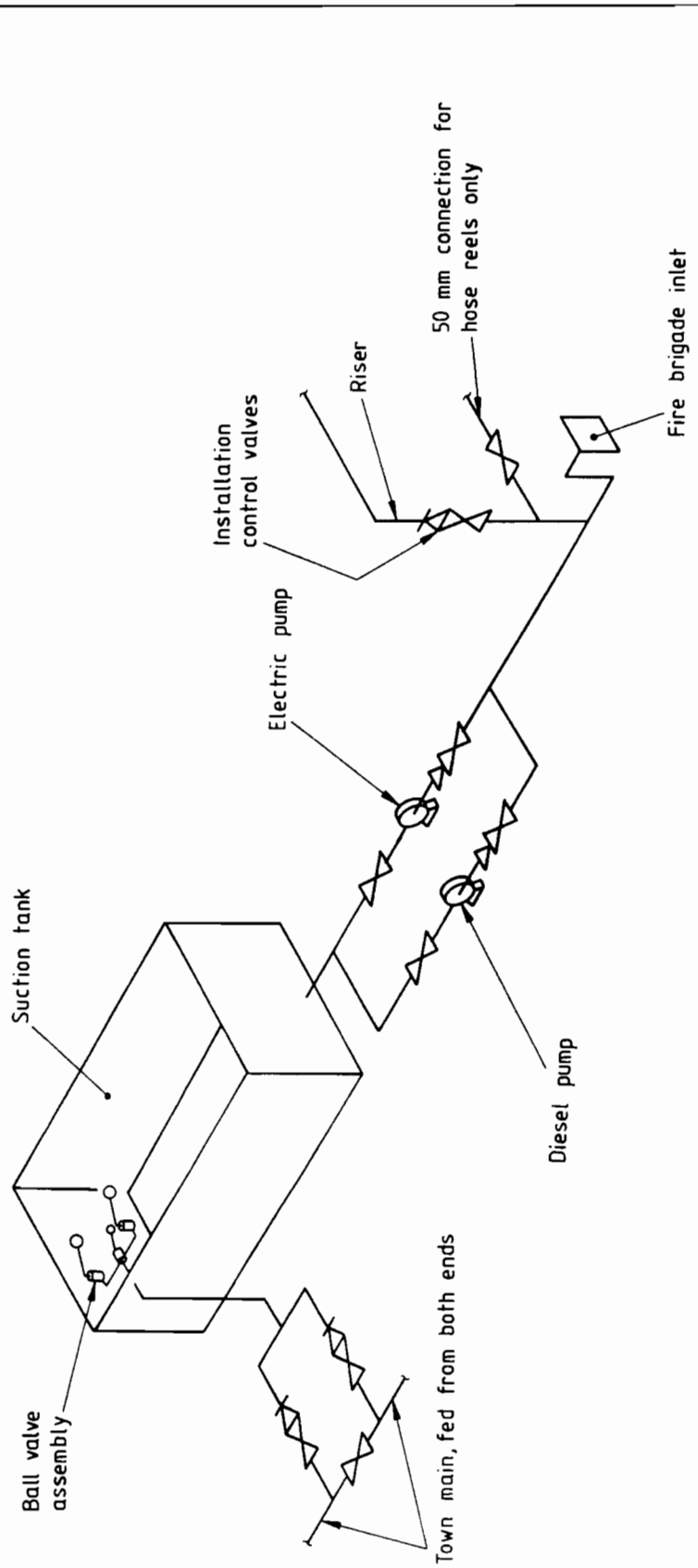


Figure 10. Superior supply using suction pumps

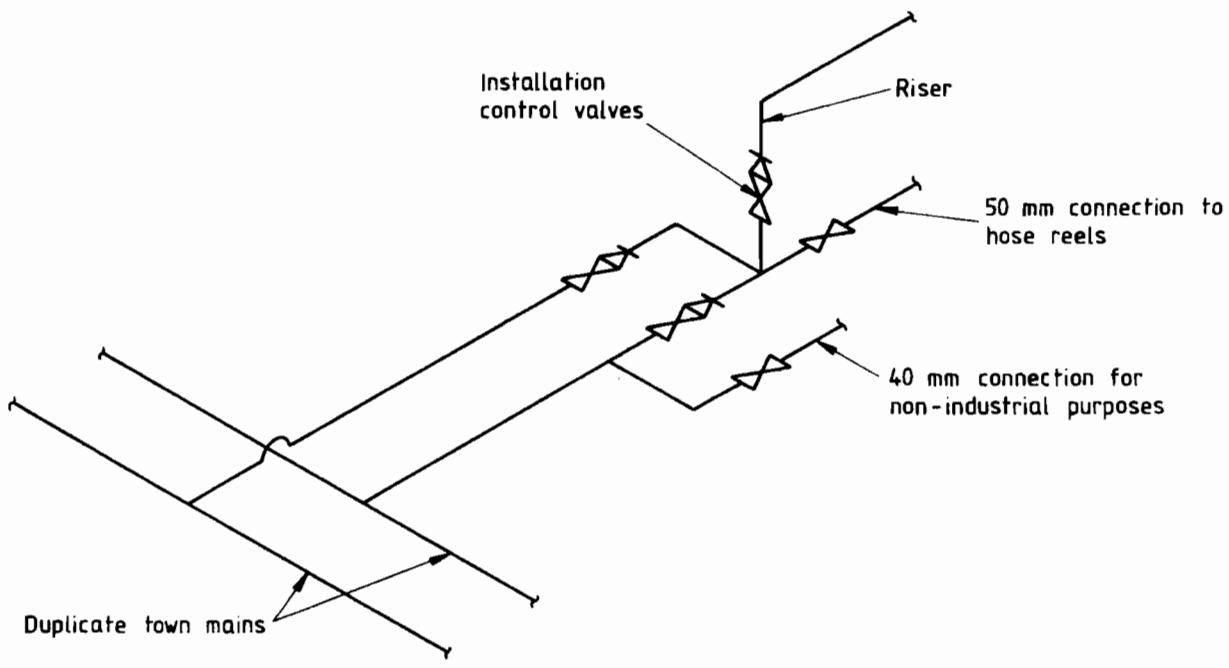


Figure 12. Duplicate supplies using two town mains

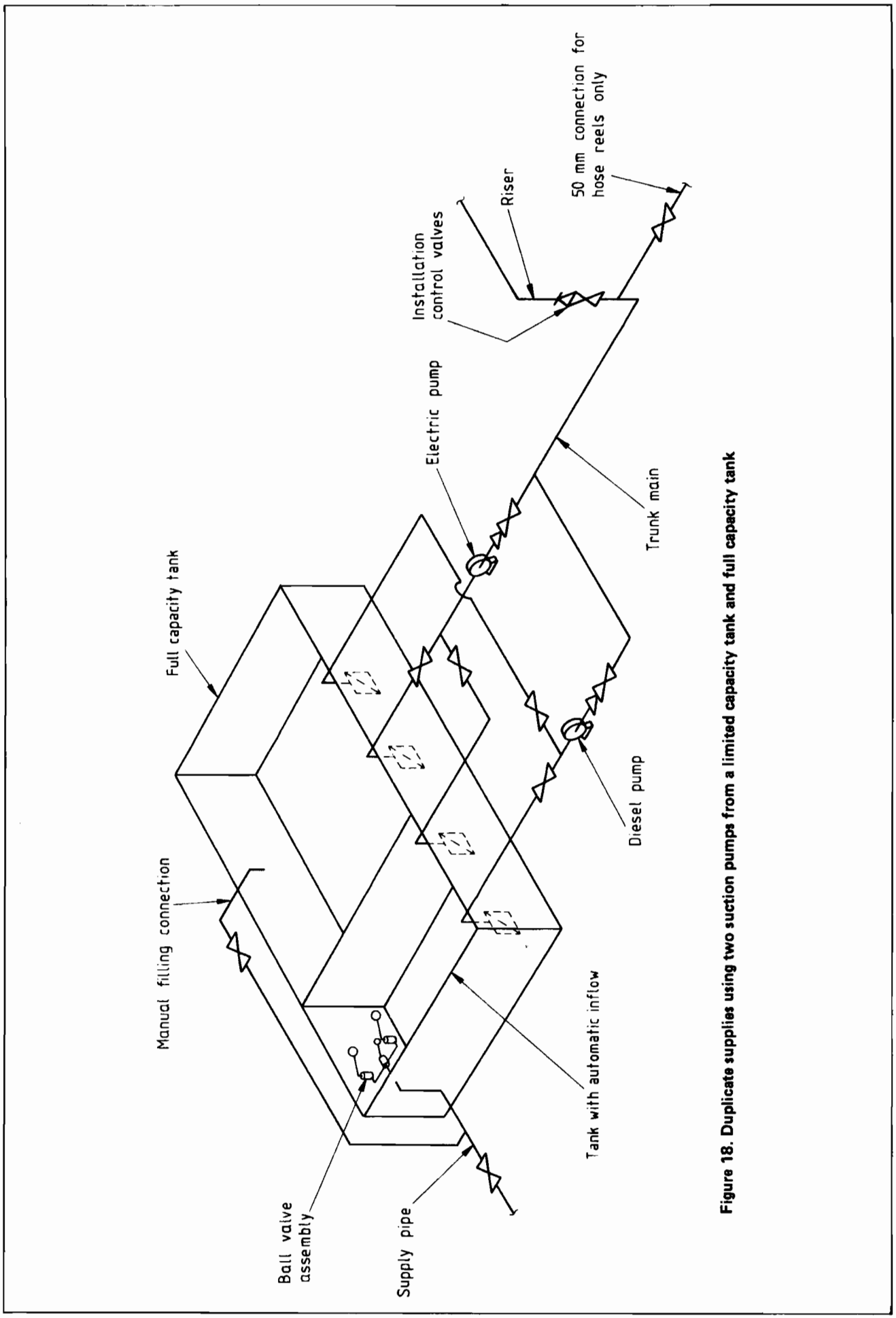


Figure 18. Duplicate supplies using two suction pumps from a limited capacity tank and full capacity tank

14 Design density and AMAO for fully hydraulically calculated installations

14.1 General

For fully hydraulically calculated installations the density of discharge, calculated as specified in clause **18**, shall be not less than the appropriate value given in this clause when all the ceiling or roof sprinklers in the room concerned, or in the AMAO, whichever is the fewer, plus any supplementary sprinklers, and/or sprayers, and/or medium-velocity sprayers, and/or high-velocity sprayers, installed below the roof or ceiling sprinklers considered to be in operation, are in operation.

COMMENTARY AND RECOMMENDATIONS ON 14.1. *The basis for full hydraulic calculation for all fire hazard classes is the specification of a minimum design density from a group of sprinklers (four in number if the number in open communication is four or more) in a specified geometric pattern (see 24.3). This group is the most hydraulically remote from the water supply, and is part of a larger group of sprinklers assumed to be discharging simultaneously. The larger group is the AMAO and is specified for each hazard class. The hydraulically most unfavourable AMAO is used to calculate design density. The shape of the AMAO is specified in 24.3.8.*

14.2 Light hazard

The design density and the AMAO of roof or ceiling sprinklers shall be not less than as given in table 7.

Not more than six sprinklers shall be installed in a room, except in either a corridor where there is a single line of sprinklers or a concealed space protected as specified in **24.1.4**(a).

14.3 Ordinary hazard

The design density and AMAO of roof or ceiling sprinklers for each of the various groups shall be not less than as given in table 7.

14.4 High hazard

14.4.1 *Process hazard.* The minimum design density and AMAO shall be not less than as given in table 7.

14.4.2 *High-piled storage hazards (goods), storage classes S1 and S4.* Where the storage height exceeds that for ordinary hazard given in table 1, the design density and AMAO of roof or ceiling sprinklers shall be not less than the appropriate value given in table 8.

14.4.3 *High-piled storage hazards (goods), storage classes S2 and S5.* Where the storage height exceeds that for ordinary hazard given in table 1, the design density and AMAO shall be not less than the appropriate value given in table 9.

COMMENTARY AND RECOMMENDATIONS ON 14.4.3. *For storage heights greater than those given in table 9, for class S5, intermediate sprinklers are specified (see 14.6). Intermediate sprinklers are strongly recommended for class S5 storage regardless of height.*

Table 7. Minimum design density and AMAO for light-, ordinary- and high-hazard (processes) roof or ceiling sprinklers

Hazard	Minimum design density	AMAO
	mm/min	m^2
Light	2.25	84
Ordinary		
Group I	5	72
Group II	5	144
Group III	5	216
Group III special	5	360
High (processes)		
Type 1	7.5	260
Type 2 (see table 4)	10.0	260
Type 3	12.5	260
Type 4	10.0	Complete deluge protection for each building

14.4.4 *High-piled storage hazards (goods), storage classes S3, S6, S7 and S8.* For goods of classes S3 and S6, stored to heights above those specified in table 1, column 3 and for goods of classes S7 and S8 the design density and AMAO shall be not less than as given in table 10.

COMMENTARY AND RECOMMENDATIONS ON 14.4.4. *For storage heights greater than those given in table 10, for classes S7 and S8, intermediate sprinklers are specified (see 14.6). Intermediate sprinklers are strongly recommended for class S7 storage regardless of height.*

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

14.4.5.1 Where intermediate sprinklers are provided as specified in **26.1.4** and the roof or ceiling sprinklers are more than 3 m above the top of the goods the roof or ceiling sprinklers shall have a design density of not less than 7.5 mm/min and an AMAO of not less than 260 m^2 and intermediate sprinklers shall be provided at each tier, including the top tier, of storage.

14.4.5.2 Where intermediate sprinklers are provided as specified in **26.1.4** and the roof or ceiling sprinklers are not more than 3 m above the top of the goods the roof or ceiling sprinklers shall have a design density and an AMAO not less than as given in table 11, and intermediate sprinklers shall be provided at each tier, except the top tier, of storage.

COMMENTARY AND RECOMMENDATIONS ON 14.4.5. *See 14.6 for discharge density from intermediate sprinklers. Maximum storage heights between levels of rack or shelf protection are specified in 26.1.4.1 and 26.1.4.2.*

Table 15. Pressure and flow requirements for ordinary-hazard installations

Hazard group	Lower flow rate		Higher flow rate	
	Pressure at 'C' gauge or section stop valve	Flow rate through installation test valve	Pressure at 'C' gauge or section stop valve	Flow rate through installation test valve
	bar	L/min	bar	L/min
I	1.0+S*	375	0.7+S*	540
II	1.4+S*	725	1.0+S*	1000
III	1.7+S*	1100	1.4+S*	1350
IIIS	2.0+S*	1800	1.5+S*	2100

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

15.2.3 *High hazard*

15.2.3.1 When tested as described in appendix A the water supply running pressure at the control valve 'C' gauge shall be not less than either:

(a) where the AMAO is not larger than the area protected

$P_r + P_f + P_s$; or

(b) where the AMAO is larger than the area protected

$P_{red} + P_f + P_s$.

where

P_{red} is the running pressure specified in tables 16, 17, 18 or 19 as appropriate at a flow rate equal to $\frac{\text{area protected}}{\text{AMAO}}$ times the flow rate specified in the table (in bar);

P_r is the running pressure at the design point and flow rate specified in tables 16, 17, 18 or 19 as appropriate (in bar);

P_f is the calculated pipe friction loss between the control valve 'C' gauge and the most hydraulically remote design point (in bar);

P_s the static pressure difference between the highest sprinkler downstream of the design point and the control valve 'C' gauge (in bar).

COMMENTARY AND RECOMMENDATIONS ON 15.2.3.1.

Note that the requirements apply where the area of the high-hazard protection in the same room (or area in which sprinklers are liable to operate simultaneously) contains fewer than 48 sprinklers but is not less than the AMAO.

In some circumstances the hydraulically most remote design point may not feed the highest sprinkler in the installation, in which case it will be necessary to verify that the water supply can also provide the pressure needed with a second design area containing the highest sprinkler (see 24.2.4.2).

15.2.3.2 Where AMAO is fed by more than one distribution pipe the pipe friction loss (see **15.2.3.1**) shall be calculated on the basis that the flow rates in the distribution pipes are in proportion to the fraction of the design area fed by each distribution pipe.

COMMENTARY AND RECOMMENDATIONS ON 15.2.3.2.

See figure 19(a) for an example of this.

15.2.4 *Mixed high/ordinary hazard.* Where the area of the high-hazard protection is less than the AMAO but there is an adjacent area of ordinary hazard in the same room (i.e. an area in which sprinklers are liable to operate simultaneously), the high-hazard area flow rate required shall be reduced by the ratio of the actual area to the AMAO (see clause **14**) and to this flow rate shall be added the flow rate for the ordinary-hazard area taken as 5.0 x the excess of the specified high-hazard AMAO over the actual high-hazard area (L/min).

When tested as described in appendix A the water supply running pressure shall be based on the level of the highest sprinkler in the high-hazard area and shall be not less than that specified in **15.2.3.1** (see also **15.3**).

The ordinary-hazard portion of the installation shall be supplied as specified in **15.2.2**, and the high-hazard distribution pipe feeding both high- and ordinary-hazard sprinklers shall be of bore not less than as specified in the ordinary-hazard pipe tables.

COMMENTARY AND RECOMMENDATIONS ON 15.2.4.

See figure 19(b) for an example of this.

15.3 Fully hydraulically calculated pipe size installations

15.3.1 *Pressure-flow requirement.* When tested as described in appendix A the water supply running pressure at the 'C' gauge shall be not less than the value calculated by the method of **24.3**.

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

Table 16. Pressure and flow requirements, for high-hazard installations, with 15 mm sprinklers (precalculated), and pipe sizes from tables 60 and 62

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

*See **26.1.3** for restrictions on use of these spacings.

Table 17. Pressure and flow requirements for high-hazard installations, with 15 mm sprinklers (precalculated), and pipe sizes from tables 60 and 63

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

*See **26.1.3** for restrictions on use of these spacings.

16 Water storage capacity

16.1 Application

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

COMMENTARY AND RECOMMENDATIONS ON 16.1. *Note that water storage capacities are given in* m^3 *and refilling rates in* L/min, *and that the factors used for calculation take account of this.*

16.2 Source of water

16.2.1 *General.* An appropriate source of water shall be provided as specified in table 20.

16.2.2 *Refilling rate for suction tanks not dependent on inflow.* The water source shall provide a refilling rate, f, of not less than 75 L/min for single tank or a duplicate tank.

16.3 Minimum capacity

16.3.1 *Town main reservoirs.* The capacity shall be not less than the appropriate design capacity, V, specified in table 20.

16.3.2 *Private elevated reservoirs and virtually unrestricted supplies.* The capacity shall be not less than the appropriate design capacity, V, specified in table 20.

16.3.3 *Pump suction tanks dependent on inflow.* The effective capacity shall be not less than the appropriate design capacity, V, specified in table 20.

16.3.4 *Pump suction tanks not dependent on inflow*

16.3.4.1 *Single tanks.* The effective capacity shall be not less than the following:

(a) if V/f is less than 1, the appropriate design capacity, V, specified in table 20; or

(b) if V/f is not less than 1, $1.33V$ or $(2V - f)$ whichever is the less.

16.3.4.2 *Duplicate tanks.* The effective capacity of each tank shall be not less than the following:

(a) if V/f is less than 0.7, the appropriate design capacity, V, specified in table 20; or

(b) if V/f is not less than 0.7, $1.33V$ or $(2V - f/0.7)$ whichever is the less.

16.3.5 *Gravity tanks.* The capacity shall be not less than the following:

(a) for high-rise systems, 2 V; or

(b) for low-rise systems, either:

(1) if V/f is less than 0.36, the appropriate design capacity, V, specified in table 20; or

(2) if V/f is not less than 0.36, $(2V - 0.36f)$.

COMMENTARY AND RECOMMENDATIONS ON 16.3.5. *Where the capacity exceeds the specified minimum a separate outlet pipe above the level corresponding to the specified minimum capacity may be used to supply water for other uses.*

Table 20. Water source and design capacity

Source of water	Pipework design method	Hazard class	Supply type	Design capacity (V) m^3
Town main reservoir	Either*	Light	Any	1000
Private elevated reservoir	Either*	Light	Any	500
Town main reservoir or private elevated reservoir † or virtually unrestricted supply (such as river lake or canal)	Either*	Ordinary, all groups	Any	1000
	Precalculated	High	Superior or duplicate	1000 plus capacity specified in table 23‡
	Fully calculated	High	Superior or duplicate	1000 plus capacity specified in table 24
Pump suction tank not dependent on inflow (Types A or B) or gravity tank	Precalculated	Light	Any	As specified in table 21
		Ordinary, all groups	Any	As specified in table 22
		High	Superior or duplicate	As specified in table 23†‡
	Fully calculated	Ordinary, all groups	Any	As specified in table 24
		High	Superior or duplicate	
Pump suction tanks dependent on inflow (Types C and D)	Either*	Ordinary, all groups	Any	As specified in table 25
		High	Superior or duplicate	
Pressure tank	Precalculated	Light	Superior or duplicate	7
		Ordinary, group 1	Superior	23
		Ordinary, all groups	Superior or duplicate	15
	Fully calculated	Ordinary, group 1	Superior or duplicate	As specified in table 24
		Ordinary, groups II, III and IIIS	Duplicate	

* i.e. precalculated or fully calculated.

† The capacities stated apply to private elevated reservoirs supplying the sprinkler system and other services.

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

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

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

Table 21. Design capacity, where tank is not dependent on inflow, for light-hazard precalculated installations

Height of highest sprinkler above lowest sprinkler not exceeding	Design capacity
m	m^3
15	9
30	10
45	11

Table 22. Design capacity, where tank is not dependent on inflow, for ordinary-hazard precalculated installations

Group	Height of highest sprinkler above lowest sprinkler not exceeding	Design capacity
	m	m^3
I	15	55
	30	70
	45	80
II	15	105
	30	125
	45	140
III	15	135
	30	160
	45	185
IIIS	15	160
	30	185

Table 23. Design capacity, where tank is not dependent on inflow, for high-hazard precalculated installations

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

Table 24. Design capacity, where tank is not dependent on inflow, for fully hydraulically calculated installations

Hazard class	Design capacity
	m^3
Light	$0.03\,Q_{max.}$
Ordinary	$0.06\,Q_{max.}$
High	$0.09\,Q_{max.}$
$Q_{max.}$ expressed in L/min	
NOTE. $Q_{max.}$ is the maximum flow demand specified in **18.3.4.**	

Table 25. Design capacity, where tank is dependent on inflow at refilling rate *f*, L/min

Hazard class	Design capacity
	m^3
Light	2.5 or, as given in table 21 or 24 less $0.03f$, whichever is the greater
Ordinary, Group I	25 or, as given in table 22 or 24 less $0.06f$, whichever is the greater
Ordinary, Group II	50 or, as given in table 22 or 24 less $0.06f$, whichever is the greater
Ordinary, Group III	75 or, as given in table 22 or 24 less $0.06f$, whichever is the greater
Ordinary, Group IIIS	100 or, as given in table 22 or 24 less $0.06f$, whichever is the greater
High	2/3 of the value given in table 23 or 24 or, the value given in table 23 or 24 less $0.09f$, whichever is the greater
NOTE. Requirements for the town main supplying the inflow are given in **17.1.4.**	

17 Town mains, elevated private reservoirs, gravity tanks, suction and booster pumps, and pressure tanks

17.1 Town mains

17.1.1 *General*

17.1.1.1 *Pressure-flow requirement.* A town main shall normally provide at the time of anticipated maximum demand for all other purposes the appropriate minimum pressure-flow specified in clause 15.

COMMENTARY AND RECOMMENDATIONS ON 17.1.1.1.
Town main standing pressure should not exceed 10 bar. *Pressure-reducing valves are not recommended and they should be used only after consultation as specified in 3.1.*

17.1.1.2 *Terminal mains.* The nominal bore of any terminal main, or branch dead-end main, feeding an ordinary hazard (group III or IIIS) or a high-hazard installation shall be not less than 150 mm.

COMMENTARY AND RECOMMENDATIONS ON 17.1.1.2.
It is preferable not to feed sprinkler installations from town main dead-end branches.

17.1.1.3 *Stop valves.* Stop valves on the branch connection from the town main, other than those under the control of the water undertaking, shall be padlocked open and be under the control of the user.

17.1.1.4 *Fully hydraulically calculated installations.* Where the installation pipework sizes are hydraulically calculated the pressure of the main or mains used for hydraulic calculations shall be as follows:

(a) if the pressure, measured during a flow test at a period of maximum demand and adjusted to take account of static head and friction losses between the test point and the position of the 'C' gauge is greater than 3.3 bar, 85 % of the measured pressure; or

(b) if the measured pressure is not greater than 3.3 bar, 0.5 bar less than the lowest test pressure.

COMMENTARY AND RECOMMENDATIONS ON 17.1.1.4.
The roof or ceiling sprinkler minimum pressure specified in 24.3.5 is to be satisfied at a pressure-flow point on or below the intercept of the installation characteristic for any AMAO position with the adjusted town supply pressure-flow graph as required.

17.1.2 *Town main as superior supply*

17.1.2.1 A town main used as a superior supply shall be:

(a) fed from each end by mains, each of which shall be capable of furnishing the pressure and flow specified in clause **15**; and

(b) not directly dependent on a common trunk main anywhere in the town main complex; and

(c) fed from more than one source.

17.1.2.2 Either

(a) duplicate connections, carried separately up to the premises containing the sprinkler system, with a stop valve (open or closed as required by the water undertaking) on the main between the two connection points, shall be made to the main; or

(b) where duplicate connections cannot be provided a single connection with a stop valve (secured open) fitted immediately on each side of the branch connection shall be used.

COMMENTARY AND RECOMMENDATIONS ON 17.1.2.2.
Where duplicate connections are used the stop valve is used as necessary to isolate part of the supply main whilst supply is maintained to the system.

17.1.3 *Two town mains as a duplicate supply.* Where two mains form a duplicate supply the mains shall be either completely independent or fed from an interconnected network having two or more reservoirs and with stop valves so positioned that in the event of a breakdown anywhere in the network one of the mains can remain operative.

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

The flow meter and pipework shall be protected from freezing.

COMMENTARY AND RECOMMENDATIONS ON 17.1.4.
The flowmeter can be used to indicate during tank filling that the specified inflow is available.

17.2 Elevated private reservoirs

The elevated private reservoir and its feed main shall be under the control of the user.

17.3 Gravity tanks

17.3.1 *General*

17.3.1.1 The tank shall not supply more than one sprinkler system.

17.3.1.2 The specified water capacity shall be maintained by automatic means.

17.3.1.3 The tank, inlet float valves, and inflow, outlet and overflow pipes shall be protected against freezing.

The tank shall be covered to exclude daylight and solid matter.

COMMENTARY AND RECOMMENDATIONS ON 17.3.1.3.
The water authority will have requirements for the float valves.

BS 6700 covers precautions against freezing. If a heating system is used it should be provided with a device to give an audible and visible warning of malfunction.

17.3.1.4 The tank shall be provided with a side-outlet overflow pipe.

COMMENTARY AND RECOMMENDATIONS ON 17.3.1.4.
The water authority will have requirements for the minimum size, and will advise on location.

Where the tank is a superior supply the size should not be less than that of the water inflow pipe; or where the tank is part of a duplicate supply the size should be not less than 100 mm.

17.3.1.5 The tank shall be fitted with a water depth indicator.

17.3.1.6 The tank shall be fitted with a permanent ladder or stair extending above the top of the tank to permit access.

COMMENTARY AND RECOMMENDATIONS ON 17.3.1.6.
Safety precautions to control access should be implemented.

17.3.2 *High-rise buildings.* The tank shall be refilled by an automatic pump controlled by duplicated on/off float switches in the tank.

COMMENTARY AND RECOMMENDATIONS ON 17.3.2.
The refilling pump need not be dedicated for this purpose only.

17.4 Suction and booster pumps

17.4.1 *Drive and power arrangements*

17.4.1.1 The pressure-flow characteristics of pumps shall be as given in table 26. Pumps shall be driven directly, by either:

(a) an electric motor with a maximum power output not less than 1.1 times the power needed to drive the pump at any flow within its characteristics; or

(b) a diesel engine with a 6 h rating (determined as specified in BS 5514), not less than 1.1 times the power needed to drive the pump at a flow of 1.1 times the maximum predicted flow.

17.4.1.2 Power to drive the pumps shall be available at all times.

The electric supply to electrically driven pumps shall be obtained from a public electricity supply or other reliable source.

COMMENTARY AND RECOMMENDATIONS ON 17.4.1.2. *Some of the authorities listed in 3.1 may have requirements relating to the approval of installers of automatic pumps.*

Where the electricity supply is not taken from a public source full particulars of the generating plant should be submitted to the authorities concerned at the planning stage.

Generating plant engine fuel tanks should be kept fully filled when in the stand-by condition.

17.4.1.3 Pumps shall be driven either:

(a) directly from the driver; or

(b) in the case of submersible pumps only through a 1:1 ratio angle gear.

The coupling between the driver and the pump shall be such that either unit can be removed without disturbing the other.

Table 26. Pump pressure, flow and speed rating

Hazard class	Pump installation type	Installation pipework design	Flow condition for nameplate pressure*, flow and speed rating	
			Flow	Pump inlet condition
Light and ordinary	Suction	Precalculated	L/min Nominal as table 28	Zero suction lift
Light and ordinary	Booster	Precalculated	Nominal as table 28	Zero town main pressure
High	Suction	Precalculated	1.35 x table 16 or 1.2 x table 17 or tables 18 or 19 (see also 15.2.3)	Zero suction lift
High	Booster	Precalculated	1.35 x table 16 or 1.2 x table 17 or tables 18 or 19 (see also 15.2.3)	Zero town main pressure
All	Suction	Fully calculated	$Q_{max.}$ (see 18.3)	Water supply at normal level (see figure 23)
All	Booster	Fully calculated	$Q_{max.}$ (see 18.3)	Zero town main pressure

*Outlet pressure at delivery side of any outlet orifice plate fitted.

17.4.1.4 Where two booster pumps provide a superior supply, or totally provide a duplicate supply, each pump when operating alone shall provide not less than the flow and pressure specified in clause **15** and shall have compatible pressure flow characteristics so that when operating in parallel it is not overloaded at any point.

Where both pumps are electrically driven either:

(a) they shall be separately driven by independent supplies; or

(b) they shall both be driven from the same supply with an automatic changeover to a completely independent supply in the event of failure of the first supply.

17.4.1.5 Where automatic suction pumps provide a superior supply or totally provide a duplicate supply they shall be arranged as either:

(a) two pump arrangements. Each pump when operating alone shall provide not less than the flow and pressure specified in clause **15**, and shall have compatible pressure-flow characteristics so that when operating in parallel it is not overloaded at any point within the specified range of output flows.

Where both pumps are electrically driven either they shall be separately driven by completely independent power supplies or from the same power supply with an automatic changeover to a completely independent supply in the event of failure of the first supply; or

(b) three pump arrangements. Each pump shall have compatible flow characteristics so that when operating in parallel it is not overloaded at any point within the specified range of output flows.

The flow and pressure specified in clause **15** shall be provided by any combination of two pumps operating in parallel, and where all three pumps are electrically driven, by one nominated pump operating alone.

Where two or three pumps are electrically driven either one pump, which shall be the nominated pump in the case of three pumps, shall be separately driven by a power supply completely independent of the supply to the other pump or pumps, or all shall be driven by the same power supply with an automatic changeover to a completely independent supply in the event of failure of the first supply.

17.4.2 *Starting and test facilities*

17.4.2.1 *Starting.* A single stage pump set shall be fitted with a starting device suitable for sprinkler service immediately downstream of the outlet check valve. A multistage high-rise pump shall be fitted with a starting device suitable for sprinkler service immediately downstream of each stage outlet check valve.

The starting device shall open a normally closed electrical circuit and cause the pumps to operate when the pressure in the water supply trunk main has fallen to a value not less than 80 % of the pressure attained in the trunk main when the pump or pumps are churning. The pumps shall be fully operational in not more than 30 s.

A push button manual start device, protected by a quick access front, shall be provided at the control panel.

Means shall be provided for emergency manual starting and for testing starting by reduction of the water pressure applied to each starting device.

Where a drain valve is fitted to test the starting device and to facilitate servicing, an isolating valve with a bypass shall be fitted on the hydraulic connection. The bypass shall incorporate a 3 mm diameter orifice and a check valve allowing flow towards the trunk main. A pressure gauge to indicate the pressure at which the pump starts shall be placed between the isolating and drain valves in such a position that it can be read during the pump starting test.

COMMENTARY AND RECOMMENDATIONS ON 17.4.2.1.
The quick access front protecting the manual start push button, if of the frangible glass type, should not produce jagged or sharp edges which might cause injury.

The drain valve should be fitted with an orifice plug to control the rate of pressure drop and should have permanent drainage facilities.

17.4.2.2 *Starting devices.* The starting devices shall be housed in an enclosure with a degree of protection not less than IP65 as specified in BS 5490.

17.4.2.3 *Stopping.* The pump shall not have any automatic stopping device.

17.4.2.4 *Alarms.* Means shall be provided to initiate visual and audible warnings in an area with responsible manning as follows:

(a) (when the pump is not running) when the sprinkler trunk main pressure falls to a value at which the pump, or the first pump when more than one forms the supply, should start; and

(b) when the water level in the priming tank is not being maintained by its normal source.

These warnings shall latch in until cancelled manually.

17.4.2.5 *Pump output test facility.* A test facility, including a direct reading flow meter suitable for sprinkler service, shall be provided at the pump delivery branch downstream of each outlet check valve to permit a running pressure test of the pump at the full load condition ($Q_{max.}$) or nominal rating as appropriate.

Where the installation main control valves are remote from the pump(s) an additional test facility shall be provided upstream of each group of control valve sets.

COMMENTARY AND RECOMMENDATIONS ON 17.4.2.5. *This facility should be such that the full load condition of the pump is not exceeded when the test valve is fully open.*

The test pipework should have means for automatic or manual drainage.

Adequate provision should be made for the disposal of the waste water, and if water is returned to the pump suction tank the arrangement should be such that aerated water is not drawn into the pump suction. Water should not be

returned directly into a jackwell or to a point close to the pump suction connection as the recirculation of the water may cause overheating and possible cavitation in the pump casing. See clause 19 for pressure flow/testing.

17.4.2.6 *Bypass on booster pumps.* Booster pumps shall be fitted with a bypass with a stop valve and a check valve. The bypass size shall be not less than the size of the water supply pipe to the pump.

17.4.2.7 *Cooling.* Means shall be provided to allow a continuous flow of water through a pump at a sufficient rate to prevent overheating of the pump when churning, with adequate provision for disposal of any cooling water run to waste.

17.4.2.8 *Location of pumps.* Water supply pumps shall be sited at or near ground level.

COMMENTARY AND RECOMMENDATIONS ON 17.4.2.8.
To maintain water pressure wet and alternate installations may be provided with a jockey pump which shall not be so large as to prevent the operation of suction or booster pumps when a single sprinkler operates. A jockey pump is specified for high-rise systems (see 15.2.2.2).

Pumps at ground level are more accessible to the fire brigade.

17.4.3 *Water sources for suction pumps*

17.4.3.1 *Single supply.* A suction pump providing a single supply shall draw water from either:

(a) a suction tank type A not dependent on inflow suitable for sprinkler service, and complying with **17.4.11**; or

(b) a suction tank type B not dependent on inflow, and complying with **17.4.11**; or

(c) a suction tank type C dependent upon inflow, and complying with **17.4.11**; the inflow shall be from a town main complying with **17.1.1.2**, **17.1.1.3** and **17.1.4**; or

(d) a virtually inexhaustible source such as a river, canal, lake, etc.

17.4.3.2 *Superior supply.* Suction pumps providing a superior supply shall draw water from either:

(a) a suction tank type B not dependent on inflow, and complying with **17.4.11.6**; or

(b) a suction tank type C dependent upon inflow, and complying with **17.4.11.6**; the inflow shall be from a town main complying with **17.1.2.1** (b) and (c), and **17.1.2.2**, and if the tank capacity is not less than two-thirds of the capacity specified for a tank not dependent on inflow for the hazard class, with **17.1.4**.

17.4.3.3 *Suction pump as duplicate supply.* Suction pumps providing a duplicate supply shall draw water from either:

(a) a suction tank type A not dependent on inflow, and complying with **17.4.11.6**; or

(b) each of two suction tanks type B not dependent on inflow, and complying with **17.4.11.6**; or

(c) each of two suction tanks type C dependent upon inflow, and complying with **17.4.11.6**. The inflow shall be from a town main complying with **17.1.4**; or

(d) a virtually inexhaustible source, such as a river, canal, lake, etc.

COMMENTARY AND RECOMMENDATIONS ON 17.4.3.
Potable water supplies are preferred to rivers, lakes, canals, etc.

17.4.4 *Water sources for booster pumps.* Booster pumps shall draw water from either a town main or an elevated private reservoir.

COMMENTARY AND RECOMMENDATIONS ON 17.4.4.
The agreement of the water authority will normally be needed before a booster pump can be connected to a town main. The water authority or water undertaker will normally require that the pump cannot draw vacuum under any water demand condition.

17.4.5 *Pump set housing*

17.4.5.1 Pump sets shall be housed as follows (in order of preference):

(a) in a separate building used for no other purpose; or

(b) in a building adjacent to, but separated by a wall of fire resistance not less than 2 h from, a protected building and with direct outside access; or

(c) in a room or enclosure, which shall be as small as is practical, enclosed by elements of construction of fire resistance not less than 2 h and with direct outside access.

COMMENTARY AND RECOMMENDATIONS ON 17.4.5.1.
Pump sets and associated equipment should be sited to avoid, and if necessary should be protected from, mechanical damage.

17.4.5.2 Houses for diesel pumps shall be sprinkler-protected. Where it is impractical to provide sprinkler protection from the installation control valve sets in the premises, sprinkler protection shall be provided from the nearest accessible point on the downstream side of the outlet check valve of the pump via a subsidiary stop valve, secured in the open position together with a flow alarm device (see **27.2**) suitable for sprinkler service to provide visible and audible indication of the operation of the sprinklers. The alarm equipment shall be installed either at the installation control valves or at a responsibly manned location such as a gatehouse.

A 15 mm nominal diameter drain and test valve shall be fitted downstream of the flow alarm to permit a practical test of the alarm system.

17.4.5.3 The pump house shall be maintained at or above temperatures of 4 °C for electric motor driven pumps, or 10 °C for diesel engine driven pumps.

17.4.5.4 Pump houses for diesel engine driven pumps shall be provided with adequate ventilation for engine aspiration.

COMMENTARY AND RECOMMENDATIONS ON 17.4.5.4.
With the engine(s) operating on full load the equilibrium temperature rise above ambient should not exceed 10 °C. *Adequate ventilation for unsealed engine starting batteries is also essential.*

17.4.6 *Pump performance*

17.4.6.1 *General.* The pump shall operate up to a flow equal to any flow needed for cooling (see **17.4.13.3**) plus the appropriate maximum flow rate specified in table 27. The outlet pressure shall fall with increased output (stable characteristic).

If a flow limiting outlet orifice plate is used it shall comply with **24.1.3**, and be integral with the pump outlet, or fixed to the pump outlet in such a way that it remains so fixed.

The k factor of a non-integral orifice plate shall be calculated from:

$$k = \frac{Q}{P^{1/2}}$$

where

Q = the flow rate (in L/min);

P = the pressure drop across the orifice plate with flow Q (in bar).

The closed outlet pressure of a suction pump with the water supply at normal maximum level shall not exceed 10 bar except for high-rise building systems. The closed outlet pressure of a booster pump with the town main at anticipated maximum pressure shall not exceed 10 bar.

In selecting pump characteristics allowance shall be made for increase in pressure as flow reduces owing to increase in driver shaft speed. Allowance shall also be made for increase or decrease in pressure caused by variation of water supply level at the pump suction flange.

COMMENTARY AND RECOMMENDATIONS ON 17.4.6.1.
See 17.4.7 for pump head conditions.

17.4.6.2 *Pump nameplate rating.* The nominal pressure, flow (excluding cooling water flow) and corresponding shaft speed rating shall be as given in table 26.

COMMENTARY AND RECOMMENDATIONS ON 17.4.6.2.
See 31.4.1 for pump name plate marking.

17.4.6.3 *Precalculated pipe size installation.* An automatic suction pump shall operate continuously at any flow rate up to the maximum specified in table 26 with a net positive suction head of not more than 5.38 m of water.

The flow at the nominal pressure rating shall be within +5 % of that specified in the tables.

COMMENTARY AND RECOMMENDATIONS ON 17.4.6.3.
In high-rise installations the friction loss between a section control valve and the pump is equivalent to that in the supply pipe of normal installations; it is allowed for in the specification and is therefore disregarded here.

The data given in tables 16, 17, 18, 19 and 28 assume that a pump is to supply water only to the sprinkler installation and any hydraulic hose reels for firefighting purposes only.

17.4.6.4 *Fully hydraulically calculated installation pipework.* An automatic suction pump shall operate continuously at any flow rate up to the maximum given in table 27 with the water supply at normal maximum level (see **18.3** for $Q_{max.}$). The pump shall operate with a net positive suction head of not more than 5.38 m of water, under any flow condition up to $Q_{max.}$.

Table 27. Pump maximum power absorption for driver sizing

Installation pipework design	Pump installation type	Type of pump drive	Flow range to be examined for maximum pump powar absorption. Zero to stated value
Precalculated	Suction or Booster	Electric or diesel	L/min Max. value in appropriate line of column 5 of table 28 or for high hazard as given in table 26
Fully calculated	Suction	Electric	Flow corresponding to zero pump outlet pressure*
		Diesel	$Q_{max.}$ (see **18.3** and table 26)
	Booster	Electric	Flow corresponding to zero pump outlet pressure*
		Diesel	$Q_{max.}$ (see **18.3** and table 26)

*Outlet pressure at delivery side of any outlet orifice plate.

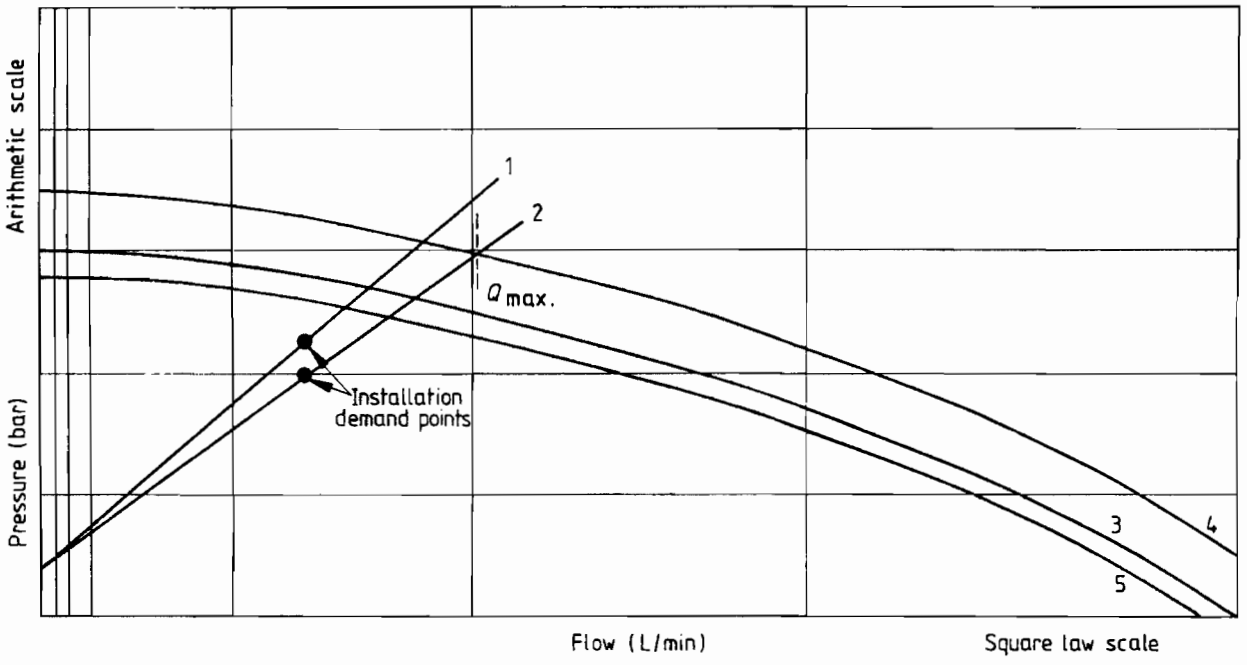
Table 28. Pump pressure and flow for light- and ordinary-hazard (precalculated) installations

Hazard class	Height difference from pump (low rise) or lowest sprinkler in installation (high rise) to highest sprinkler in installation		Nominal rating including any outlet orifice plate		Characteristic not less than			
					High flow		Low flow	
	more than	not more than	Pressure at pump outlet	Flow	Pressure at 'C' gauge	Flow	Pressure at 'C' gauge	Flow
	m	m	bar	L/min	bar	L/min	bar	L/min
Light	0	15	1.5	300	3.7	225	–	–
	15	30	1.8	340	5.2	225	–	–
	30	45	2.3	375	6.7	225	–	–
Ordinary, Group I	0	15	1.2	900	2.2	540	2.5	375
	15	30	1.9	1150	3.7	540	4.0	375
	30	45	2.7	1360	5.2	540	5.5	375
Ordinary, Group II	0	15	1.4	1750	2.5	1000	2.9	725
	15	30	2.0	2050	4.0	1000	4.4	725
	30	45	2.6	2350	5.5	1000	5.9	725
Ordinary, Group III, non-high rise	0	15	1.4	2250	2.9	1350	3.2	1100
	15	30	2.0	2700	4.4	1350	4.7	1100
	30	45	2.5	3100	5.9	1350	6.2	1100
Ordinary, Group III, high rise	0	15	1.4+S*	2250	2.9+S*	1350	3.2+S*	1100
	15	30	2.0+S*	2700	4.4+S*	1350	4.7+S*	1100
	30	45	2.5+S*	3100	5.9+S*	1350	6.2+S*	1100
Ordinary, Group IIIS	0	15	1.9	2650	3.0	2100	3.5	1800
	15	30	2.4	3050	4.5	2100	5.0	1800

*S is the pressure equivalent to the height difference between the pump and the lowest sprinkler in the installation.

COMMENTARY AND RECOMMENDATIONS ON 17.4.6.4. *To ensure that the commissioned installation conforms to the above requirements, it is usual at the design stage, to check that the pressure at the pump outlet flange measured with the water supply source at low level 'X' (see figure 23) and at the installation demand flow rate (that is the flow needed to give the minimum discharge density at the most hydraulically remote AMAO plus that for any intermediate sprinklers) is not less than 0.5 bar plus the pressure calculated to provide the flow.*

This requirement for net positive suction head (NPSH) applies to pump performance (see 17.4.10) which specifies the maximum NPSH for the pipework. The roof or ceiling sprinkler minimum pressure requirement of 24.3.4 is to be satisfied at a pressure-flow point on or below the intercept of the installation characteristic for any AMAO position on curve 5 of figure 20.



Key:

1 Hydraulically most unfavourable location
2 Hydraulically most favourable location
3 Site performance – low water level 'X' (at pump outlet)
4 Site performance – tank full (at 'C' gauge)
5 Site performance – low water level 'X' (at 'C' gauge)

Maximum predicted flow ($Q_{max.}$) 3010 L/min	Hazard Name and location of protected premises	Title. Installer's data sheet Hydraulic summary
Maximum flow to NPSH 5.38 m 5200 L/min	Installing engineers	Drawn Doc. Ref. Issue Checked Date

Figure 20. Typical installer's pump data sheet

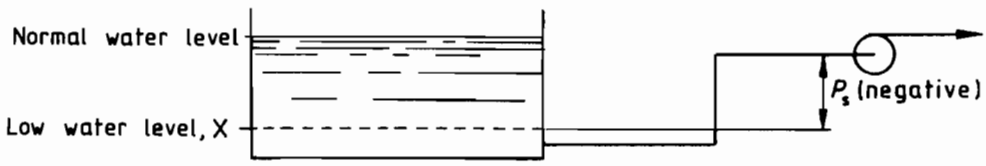


Figure 21. Measurement of negative suction head

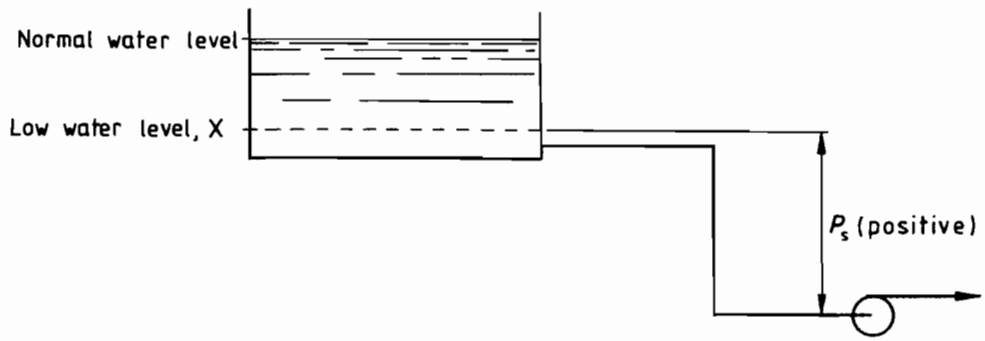


Figure 22. Measurement of positive suction head

17.4.7 *Suction conditions.* A pump shall be regarded as being under positive suction head if it draws water from either:

(a) a stored water supply where not more than 2 m depth of water or one-third of the effective capacity whichever encompasses the smaller water volume is contained between the pump centre line and the low water level 'X' (see figure 23); or

(b) a natural unlimited water supply such as a river, canal, lake, etc. where the centre line of the pump is at least 0.85 m below the lowest known water level;

otherwise it shall be regarded as being under suction lift.

COMMENTARY AND RECOMMENDATIONS ON 17.4.7.
Positive suction head is the preferred suction condition.

17.4.8 *Positive suction head conditions*

17.4.8.1 *Suction pipe.* It shall not be possible for air to be trapped in the pipe.

The suction pipes to different pumps shall only be interconnected if each individual pump suction inlet and each suction pipe connection to its water supply is fitted with a stop valve (retained in position by means other than the pump inlet flange). Any connection between suction pipes shall be upstream of the stop valve at the pump suction inlet and shall be of the same nominal inside diameter as the individual suction pipes.

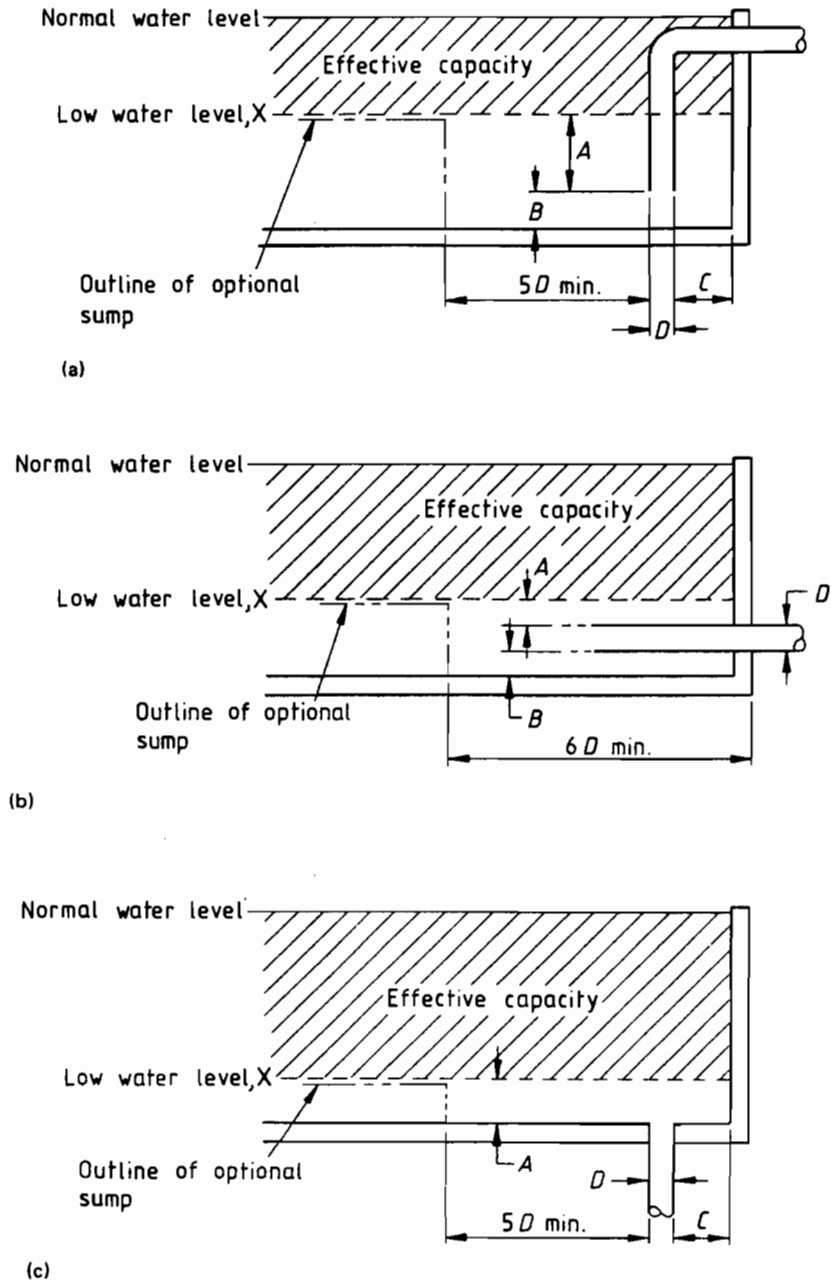
For fully hydraulically calculated pipework the suction pipe and fittings shall be sized to give a maximum water velocity of 1.8 m/s at Q_{max}.

For precalculated pipework the equivalent length of the suction pipe and fittings shall be not more than 30 m, and the suction pipe and fittings shall be sized as specified in table 29.

Table 29. Suction pipe size: positive suction head condition

Hazard class	Minimum nominal size of suction pipe*
	mm
Light	65
Ordinary, groups I and II	150
Ordinary, groups III and IIIS	200
High	$3.43\,Q^{1/2}$ where Q is the flow rate given in table 27

*A larger size may be needed to meet the requirements of 17.4.10.



NOTE 1. Provision of a sump effectively increases capacity because low water level 'X' can be at the level of the main base of the tank.

NOTE 2. See table 32 for values of *A*, *B* and *C*.

Dimension 'A' is the distance between low water level, 'X', and the highest point of water entry into the pipe.

Dimension 'B' is the distance between the base of the tank, or sump if provided, and the lowest edge of the pipe, or in case (a) if a vortex inhibitor is fitted, the underside of the upper flange of the vortex inhibitor.

Dimension 'C' is the distance from the wall to the nearer edge of the pipe bore, or if a vortex inhibitor is fitted, the near periphery of the vortex inhibitor.

Figure 23. Effective capacity of suction tanks

17.4.12 *Electric motor driven pumps*

17.4.12.1 *Power supply.* The power supply circuit for the motor shall be separate from all other circuits in the premises.

Each connection to the power supply shall be via an isolating protective device, e.g. an isolating switch-fuse, reserved solely for sprinkler service and independent of any other main or sub-main circuit. Such devices shall be secured against unauthorized operation and shall, except for maintenance, be kept locked on.

Switchrooms supplying power to sprinkler pump motors shall be situated where access by the fire brigade is readily available.

COMMENTARY AND RECOMMENDATIONS ON 17.4.12.1.
The switches controlling the supply should be readily accessible to the fire brigade.

31.5.3 specifies the labelling of any switch in the power supply to pumps.

17.4.12.2 *Supply indicator lamps.* Duplicate indicator lamps shall be provided in the vicinity of the pump to show that power is available for the motor. Where the supply is A.C. the failure of any one phase of the supply shall be indicated.

COMMENTARY AND RECOMMENDATIONS ON 17.4.12.2.
The indicator lamps should be placed so that they can be readily seen by maintenance personnel.

17.4.12.3 *Automatic power failure alarm.* Visual and audible automatic warning of power failure to the motor starting switch, or in the case of an A.C. supply failure of any one phase, shall be given at an area with responsible manning.

COMMENTARY AND RECOMMENDATIONS ON 17.4.12.3.
The alarms should be located at a continuously manned location such as a gatehouse (see 27.4).

17.4.12.4 *Electric circuit protection.* The electricity supply shall be fitted with high rupturing capacity fuses capable of carrying the stalled motor current for a period of not less than 75 % of the period needed for the motor windings to fail.

Any no-volt release mechanism shall be of the automatic resetting type so that on restoration of the supply the motor can be restarted automatically if the trunk main pressure falls.

Magnetic and thermal overload trips shall not be used.

17.4.12.5 *Cables and cable routes.* Motor supply cables inside buildings shall be:

(a) category AWX or SWX cables complying with BS 6387; or

(b) mineral-insulated copper-sheathed cables complying with BS 6207; or

(c) protected from direct exposure to fire.

External overhead cables shall not be used within 6 m of any window, door or other opening in:

(1) any sprinkler-protected building; or

(2) any building within 15 m of a sprinkler-protected building.

Where there are two or three electrically driven pumps, failure (by mechanical breakdown or fire damage) of equipment or cables supplying any pump shall not affect the supply to the other pumps.

COMMENTARY AND RECOMMENDATIONS ON 17.4.12.5.
All wiring associated with the electric motor driven pump, including the monitoring circuits (see 17.4.12.2 and 17.4.12.3) should be in accordance with the Regulations for Electrical Installations (Wiring Regulations) (15th Edition, 1981, IEE).

To protect cables from direct exposure to fire they should be run outside the building, or through those parts of the building where the fire risk is negligible and which are separated from any significant fire risk by walls, partitions or floors with a fire resistance of not less than 30 min, or they should be given additional direct protection.

17.4.13 *Diesel engine driven pumps*

17.4.13.1 *General.* A diesel engine shall be capable of operating continuously at full load at site elevation for a period of 6 h with a rated output in accordance with BS 5514 of not less than that specified in **17.4.1.1**.

The engine and equipment shall:

(a) be of the mechanical injection type starting without the use of wicks, cartridges, heater plugs or ether at an engine room temperature of 4 °C;

(b) accept full load within 15 s of the initiation of the start signal;

(c) be naturally aspirated, super-charged or turbo-charged;

(d) have a manually operated shut-down mechanism;

(e) be provided with a governor to control engine speed within ± 4.5 % of rated speed under any condition of load up to the full load rating;

(f) be fitted with a device to measure running time and a tachometer.

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

17.4.13.2 *Air intake.* The engine air intake shall be as follows:

(a) fitted with a filter of adequate size to prevent the entry of foreign matter; and

(b) protected from water discharge from the sprinklers fitted in the engine room (see **17.4.5.1**).

Table 35. Pressure tank minimum air pressures (P_f = 0.3 bar) (precalculated installations)

Hazard class	Air space in tank Volume of tank (R)	Minimum air pressure
		bar
Light	One-third	8.6 + 0.30*h*
Light	One-half	5.4 + 0.20*h*
Light	Two-thirds	3.8 + 0.15*h*
Ordinary, Group I	One-third	5.0 + 0.30*h*
Ordinary, Group I	One-half	3.0 + 0.20*h*
Ordinary, Group I	Two-thirds	2.0 + 0.15*h*
Ordinary, Group II	One-third	6.2 + 0.30*h*
Ordinary, Group II	One-half	3.8 + 0.20*h*
Ordinary, Group II	Two-thirds	2.6 + 0.15*h*
Ordinary, Group III	One-third	7.1 + 0.30*h*
Ordinary, Group III	One-half	4.4 + 0.20*h*
Ordinary, Group III	Two-thirds	3.0 + 0.15*h*
Ordinary, Group IIIS	One-third	8.0 + 0.30*h*
Ordinary, Group IIIS	One-half	5.0 + 0.20*h*
Ordinary, Group IIIS	Two-thirds	3.5 + 0.15*h*

*h is the height (in m) of the highest sprinkler above the tank base.
h = 0 if all sprinklers are below the tank base.

18 Hydraulic calculation and pipe sizing tables

18.1 General

Pipe size and layout shall be based on either:

(a) full hydraulic calculation in which case the basic hydraulic performance shall be as specified in clause **14**. Notwithstanding the density requirements of this clause, no roof or ceiling sprinkler in a fully hydraulically designed system shall discharge at a pressure less than that required in **24.3.4** with the AMAO positioned anywhere in the pipe layout; or

(b) only for installations not including intermediate sprinklers, the pipe sizing tables with hydraulic calculation of portions of the feed pipework as specified in clause **24**.

COMMENTARY AND RECOMMENDATIONS ON 18.1.
Any extensions to a precalculated installation should not be fully hydraulically calculated.

18.2 Calculation of pipework losses

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

static pressure difference, $p = 0.1h$ (bar)

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

18.2.2 *Pipe friction loss.* Frictional pressure loss in pipes shall be calculated from the Hazen-Williams formula:

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

For pipes listed in table 36 this can be simplified to:

$$p = k \times L \times Q^{1.85}$$

where

p = loss of pressure in pipe (in bar);

Q = flow rate through pipe (in L/min);

d = mean bore of pipe (see table 36) (in mm);

C = a constant for the type and condition of the pipe (see below);

k = a constant for the size, type and condition of the pipe (see table 36);

L = equivalent length of pipe and fittings (in m).

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

Pipe type	*C*
cast iron	100
ductile iron	110
mild steel	120
galvanized steel	120
spun cement	130
copper	140
unplasticized PVC	140
asbestos cement	140

Table 36. Mean size and values of '*k*' of various pipes

Nominal size	Steel pipe											
	See BS 1387								See BS 3600 Wall thickness: 5.0 mm for 150 mm pipe 5.4 mm for 200 mm pipe 7.1 mm for 250 mm pipe			
	Not galvanized medium		Not galvanized heavy		Galvanized medium		Galvanized heavy		Not galvanized		Galvanized	
	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*
	mm		mm		mm		mm		mm		mm	
20	21.63	2.71×10^{-5}	20.41	3.60×10^{-5}	21.46	2.82×10^{-5}	20.24	3.75×10^{-5}	–	–	–	–
25	27.31	8.72×10^{-6}	25.68	1.18×10^{-5}	27.14	8.99×10^{-6}	25.51	1.22×10^{-5}	–	–	–	–
32	35.97	2.28×10^{-6}	34.34	2.86×10^{-6}	35.80	2.33×10^{-6}	34.17	2.93×10^{-6}	–	–	–	–
40	41.86	1.09×10^{-6}	40.23	1.32×10^{-6}	41.69	1.11×10^{-6}	40.16	1.33×10^{-6}	–	–	–	–
50	52.98	3.46×10^{-7}	51.36	4.02×10^{-7}	52.81	3.51×10^{-7}	51.19	4.09×10^{-7}	–	–	–	–
65	68.67	9.78×10^{-8}	67.04	1.10×10^{-7}	68.50	9.90×10^{-8}	66.87	1.11×10^{-7}	–	–	–	–
80	80.68	4.46×10^{-8}	79.06	4.92×10^{-8}	80.51	4.51×10^{-8}	78.89	4.97×10^{-8}	–	–	–	–
100	105.14	1.23×10^{-8}	103.31	1.34×10^{-8}	104.97	1.24×10^{-8}	103.14	1.35×10^{-8}	–	–	–	–
150	155.32	1.84×10^{-9}	154.30	1.90×10^{-9}	155.15	1.85×10^{-9}	154.13	1.91×10^{-9}	158.30	1.67×10^{-9}	158.13	1.68×10^{-9}
200	–	–	–	–	–	–	–	–	208.30	4.40×10^{-10}	208.13	4.42×10^{-10}
250	–	–	–	–	–	–	–	–	258.80	1.52×10^{-10}	258.63	1.53×10^{-10}

	Cast iron pipe							
	Cast iron flanged See BS 2035 Class C		Cast grey iron (Cast flanges) See BS 4622		Centrifugally cast ductile iron (Screwed flanges) See BS 4772		Centrifugally cast iron See BS 1211 Class C	
	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*	mean size	value of *k*
	mm		mm		mm		mm	
50	51.95	5.33×10^{-7}	–	–	–	–	–	–
80	77.41	7.64×10^{-8}	81.23	6.05×10^{-8}	83.31	4.48×10^{-8}	81.90	5.81×10^{-8}
100	102.87	1.91×10^{-8}	100.45	2.15×10^{-8}	103.91	1.53×10^{-8}	107.33	1.56×10^{-8}
150	153.96	2.69×10^{-9}	150.50	3.00×10^{-9}	154.68	2.20×10^{-9}	159.73	2.25×10^{-9}
200	205.01	6.66×10^{-10}	200.50	7.41×10^{-10}	205.23	5.55×10^{-10}	211.62	5.71×10^{-10}
250	256.00	2.26×10^{-10}	250.60	2.50×10^{-10}	256.03	1.89×10^{-10}	263.49	1.96×10^{-10}

	Copper pipe See BS 2871 : Part 1 Table X	
	mean size	value of *k*
	mm	
22	20.21	2.84×10^{-5}
28	26.21	8.01×10^{-6}
35	32.63	2.75×10^{-6}
42	39.63	1.07×10^{-6}
54	51.63	2.95×10^{-7}
76.1	73.22	5.38×10^{-8}
108	105.12	9.24×10^{-9}
133	130.37	3.24×10^{-9}
159	155.37	1.38×10^{-9}

NOTE. The values of *C* used to calculate *k* are those listed in **18.2.2.**

1387M
1100 lpm 80ϕ 19.1 mb ; 1350 lpm 27.9 mb
100ϕ 5.25 mb ; 7.67 mb
150 0.78 mb 0.77 mb

Table 37. Equivalent length of fittings and valves

Fittings and valves	Equivalent length of medium grade steel straight pipe (in m) (*C* value 120*) according to BS 1387										
	Nominal diameter (mm)										
	20	25	32	40	50	65	80	100	150	200	250
	m	m	m	m	m	m	m	m	m	m	m
90 ° screwed elbow	0.63	0.77	1.04	1.22	1.46	1.89	2.37	3.04	4.30	5.67	7.42
90 ° welded elbow (*r*/*d* = 1.5)	0.30	0.36	0.49	0.56	0.69	0.88	1.10	1.43	2.00	2.64	3.35
45 ° screwed elbow	0.34	0.40	0.55	0.66	0.76	1.02	1.27	1.61	2.30	3.05	3.89
Standard screwed Tee or cross (Flow through branch)	1.25	1.54	2.13	2.44	2.91	3.81	4.75	6.10	8.61	11.34	14.85
Gate valve – straightway (flanged fitting)	–	–	–	–	0.38	0.51	0.63	0.81	1.13	1.50	1.97
Alarm or non return valve (swinging) flanged fitting	–	–	–	–	2.42	3.18	3.94	5.07	7.17	9.40	12.30
Alarm or non return valve (mushroom) flanged fitting	–	–	–	–	12.08	18.91	19.71	25.36	35.88	47.27	61.85
Butterfly valve (flanged fitting)	–	–	–	–	2.19	2.86	3.55	4.56	6.38	8.62	9.90
Globe valve – straightway (flanged fitting)	–	–	–	–	16.43	21.64	26.80	34.48	48.79	64.29	84.11

*These equivalent lengths can be converted as necessary for pipes of other *C* values by multiplying by the following factors:

C value	100	110	130	140
Factor	0.714	0.850	1.160	1.330

NOTE. For all other pipe joints and fittings see manufacturer's data sheets.

18.2.3 *Fitting and valve friction losses.* Frictional pressure loss in valves and fittings where the direction of water flow is changed through 45 ° or more shall be calculated by the method of **18.2.2** using the appropriate equivalent length given in table 37.

COMMENTARY AND RECOMMENDATIONS ON 18.2. *Losses due to velocity head and the change of direction into sprinklers and sprinkler dry drop or riser assemblies are disregarded here but are taken into account in the sprinkler 'k' factor.*

18.3 Calculation of the maximum flow demand of a fully hydraulically calculated installation

18.3.1 The datum point for pressures and heights shall not be downstream from the control valve 'C' gauge.

18.3.2 At any pressure, P, the flow demand, Q, of the installation shall be taken as the sum of:

(a) the flow to the roof or ceiling sprinklers with the AMAO in the hydraulically most favourable location; plus

(b) the flow to any non-rack intermediate sprinklers associated with (a); plus

(c) the simultaneous hydraulically balanced flow to any rack or shelf sprinklers in their specified number and hydraulically most favourable location.

18.3.3 The pressure-flow demand characteristics of the installation shall be determined either:

(a) by calculation (as specified in **18.3.2**) of sufficient values of Q to determine the intercept of the installation characteristic curve with the water supply characteristic curve; or

(b) by calculation (as specified in **18.3.2**) of a single value of Q, from the equation:

$$P = (P_0 - 0.1h)\left(\frac{Q}{Q_0}\right)^2 + 0.1h$$

where

P is the pressure at flow Q measured at the datum point (in bar);

P_0 is the pressure corresponding to the calculated installation flow demand measured at the datum point (in bar);

Q is the flow demand at pressure P (in L/min);

Q_0 is the calculated installation flow demand for pressure P_0 (in L/min);

h is the height of the highest sprinkler in the AMAO under consideration above the datum point (in m).

Extrapolate the pressure-flow demand graph to intersect the water supply pressure-flow characteristic. The point of intersection gives $Q_{max.}$.

18.3.4 The maximum flow demand shall be taken as the flow, $Q_{max.}$, at the point of intersection of the pressure-flow demand characteristic of the installation and the water supply pressure-flow characteristic at either low water level 'X' (curve 3 in figure 20) or in the tank full condition (curve 4 in figure 20) whichever gives the higher value.

18.3.5 At the maximum flow demand the pressure at the datum point shall be not less than:

(a) for town mains, as specified in **17.1.1.4**;

(b) for water supplies except town mains, P_0.

COMMENTARY AND RECOMMENDATIONS ON 18.3. *It is necessary to ascertain $Q_{max.}$ to verify the suitability of water supplies and their storage capacities (for a typical case see figure 20). The installation demand curve for a fully hydraulically calculated installation will originate from a pressure-flow calculation for the AMAO in the hydraulically most favourable position, i.e. where the flow rate into the installation AMAO will be highest for a given available pressure. This calculation will usually be based on the minimum allowable average density at the most unfavourably placed group of four sprinklers in the AMAO. The total flow given by the calculation will therefore be less than the actual flow $Q_{max.}$ produced by the water supply (particularly as the water supply also has to satisfy the minimum pressure requirement of 18.4 and 24.3.4, and in the case of pump supplies the requirements of 17.4.6.4, i.e. in figure 20 curve 3 may be above curve 4 where the water supply is unlimited).*

See clause 25 for sprinkler flow characteristics, clause 24 for AMAO shapes and positions, and clause 14 for basic hydraulic performance (AMAO areas, discharge densities, etc.)

18.4 Calculation of maximum installation pressure demand (fully hydraulically calculated installations)

The calculation shall be made as follows.

Make a pressure-flow calculation for the minimum allowable density from the most remote group of four sprinklers in the AMAO hydraulically most remote from the installation control valves (see clause **14** and **24.3.4**). Where there are both roof or ceiling sprinklers and intermediate sprinklers, use the true hydraulically most unfavourable locations of each taken together, irrespective of their actual locations in the building. Extrapolate the result onto the water supply pressure-flow characteristic graph as described in **18.3**.

The water supply pressure at the point of intersection of the graphs shall be not less than that given by the minimum density calculation, except in the case of town main supplies where an excess supply pressure requirement over that for minimum density is specified (see **17.1.1.4** and **17.4.6.4**).

18.5 Hydraulic balance calculations

18.5.1 *Balance across junctions.* Hydraulic calculations for each pipe junction where flows join or separate for each position of the AMAO or for each group of intermediate sprinklers assumed to be in operation shall be sufficiently accurate that:

(a) the calculated flow rate(s) into the junction are within ± 2 L/min of the calculated flow rate(s) out of the junction;

(b) all values of the pressure calculated for the junction are within ± 0.005 bar of the mean value.

18.5.2 *Overall balance.* For each position of the AMAO the sum of the calculated sprinkler discharge values of all sprinklers discharging simultaneously (using the calculated nozzle pressure in each case to establish the outlet flow) shall be within ± 1 % of the hydraulically calculated total flow into the installation.

19 Pressure-flow tests on water supplies

19.1 Test facility

An installation, unless its control valve set is sited adjacent to more hydraulically unfavourable (relative to the water supply) control valve set of an installation of the same hazard class, shall be permanently provided with devices, suitable for sprinkler service, for measuring pressure and flow for compliance with **19.2** and as specified in **35.2.5**. It shall be possible to read the control valve 'C' gauge at the same time as the measuring devices.

Adequate facilities shall be provided for the disposal of test water (see commentary and recommendations on **17.4.2.5**).

COMMENTARY AND RECOMMENDATIONS ON 19.1. *The test facility should normally utilize the installation drain pipework (see 20.1.6). Pressure-flow tests are conducted as follows:*

(a) full flow rate tests

(1) acceptance tests (see clause 10);

(2) quarterly test of town main, elevated private reservoir and gravity tank supplies (see 35.2.5);

(3) tests of suspected deteriorating automatic pump and pressure tank installation feed mains (see 35.2.5);

(b) periodic check tests

(1) quarterly reduced flow rate test of automatic pump and pressure tank supplies to ascertain the condition of the feed mains (see 35.2.5).

As automatic pump and pressure tank supplies are designed specifically to meet the pressure-flow conditions required by the hazard it is not normally considered necessary to call for practical flow tests except to test the condition of the feed mains and to check the pump performance at the bypass test facility (see 17.4.2.5).

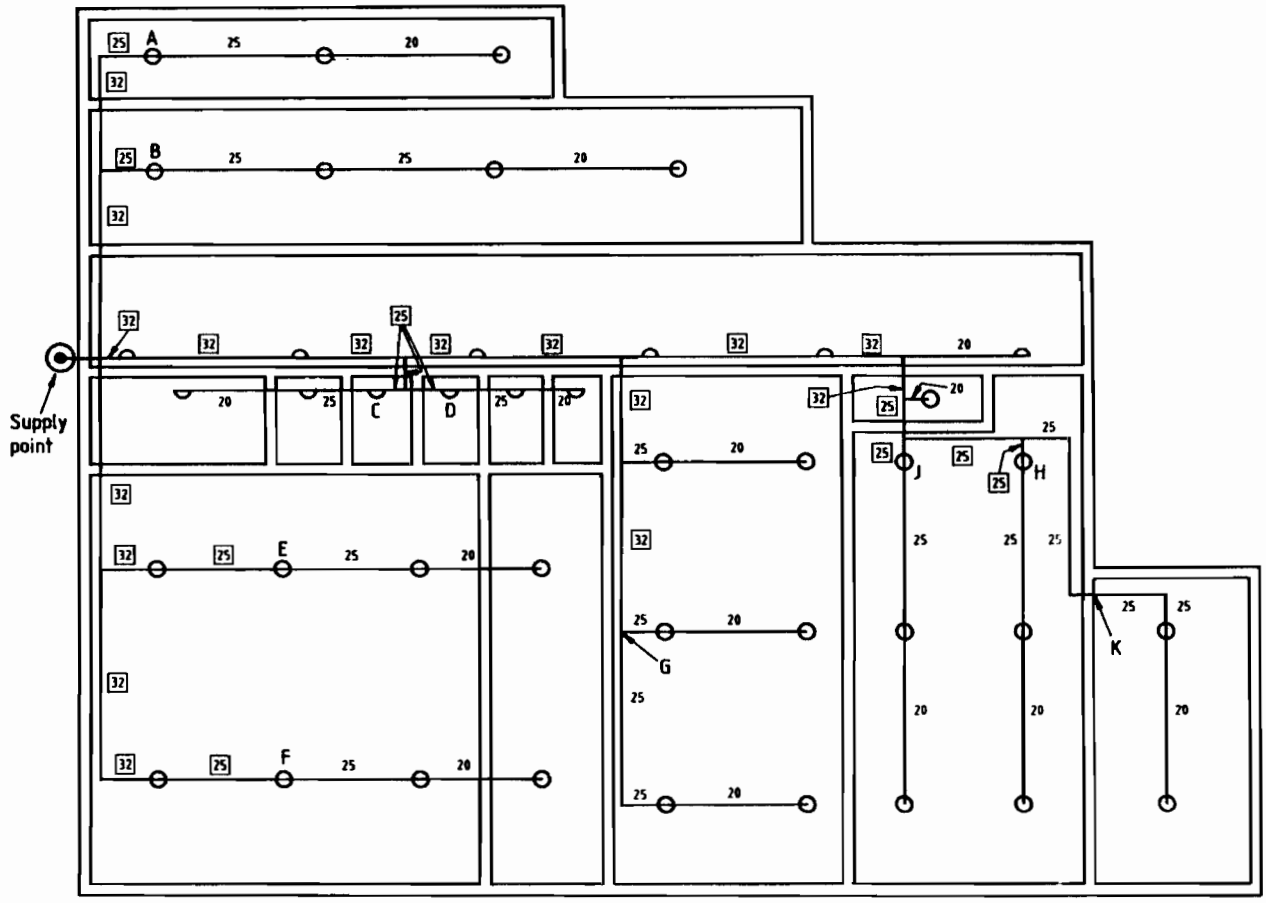
Where there are town main or automatic pump supplies for fully hydraulically calculated pipe size installations, only a fraction of the available town main or pump supply pressure is regarded as being available to meet the pressure-flow requirements (see 18.4, 17.1.1.4 and 17.4.6.4).

Where the supply is solely by automatic pump or pumps and these are immediately adjacent to the installation control valves the pump outlet test facility (see 17.4.2.5) may suffice for pressure-flow testing, correcting the pressure obtained in the flow test to the equivalent value at the control valve 'C' gauge using the calculation methods of 18.2.

Dry or alternate control valve sets (main or tail-end) may have an additional flow test valve arrangement of unspecified flow loss characteristic fitted below the alarm valve, downstream of the main stop valve, to facilitate informal supply pressure testing. Such flow test valves and pipework should have a nominal diameter of 40 mm *for light-hazard installations and of* 50 mm *for ordinary- and high-hazard installations.*

19.2 Full flow rate test

When tested the water flow and pressure shall be as specified in clause **15**.



NOTE 1. Pressure loss between supply point and: A (two sprinkler point) is 0.7 bar
B (three sprinkler point) is 0.7 bar
C, D, E, F, G, H, J and K (two sprinkler points) is 0.9 bar

NOTE 2. Dimensions shown as [25] or [32] indicate probable pipe sizes resulting from hydraulic design of arrangement.

NOTE 3. Pipe sizes are in mm.

Figure 28. Example of application of design points in a light-hazard installation

24.2 Precalculated sprinkler pipe arrays

24.2.1 *General*

24.2.1.1 Range pipe sizes and the maximum number of sprinklers fed by each size of pipe in the range shall be neither more nor less than as specified in **24.2.2**, **24.2.3**, and **24.2.4** according to range pipe layout (except in the case of light-hazard where the pipes feeding the terminal three sprinklers on a range only are specified).

24.2.1.2 The size of distribution feed pipes, including in light-hazard installations any which are partly range pipes because of the three sprinkler limitation, shall be as specified in the tables from the terminal point(s) up to the design point(s).

24.2.1.3 Feed pipe between the installation main control valves and the design point shall be hydraulically calculated on the basis of a maximum flow loss (specified in the appropriate subclause), corrected for static head gain for design points not at the highest level, at a particular flow rate.

24.2.1.4 Where the number of sprinklers in an array in a room, or in an area protected by a distinct group of sprinklers having its own distribution pipe spur, is less than or equal to the number of sprinklers for which the distribution pipes are hydraulically designed, the design point shall be positioned at the point of connection to the distribution pipe of the range of the array which is hydraulically nearest to the installation control valves (see C in figure 29).

24.2.1.5 Where the number of sprinklers in an array in a room on a distribution pipe terminal spur exceeds the number for which the distribution pipes are hydraulically designed, the design point shall be positioned at the point of connection to the range or ranges immediately upstream of the group of ranges containing not more than the maximum specified number of sprinklers beyond the design point (see figures 28 to 32).

24.2.1.6 Risers or drops, connecting ranges to distribution pipes, and pipes longer than 300 mm connecting single sprinklers to distribution pipes, shall be considered to be distribution pipes and sized accordingly. The design point shall be positioned at the point of connection of the riser, drop or single sprinkler pipe to the horizontal distribution pipe run when designing the hydraulically determined length of feed pipe (see figure 1 where pipe A is sized according to the distribution pipe tables).

24.2.1.7 Pipe diameters shall not increase in the direction of flow of water to any sprinkler.

COMMENTARY AND RECOMMENDATIONS ON 24.2.1.

The maximum number of sprinklers beyond the design point is specified in tables 54, 58, 62 and 63.

Note that the water supply running pressures are specified relative to the height of the highest sprinkler above the control valve 'C' gauge, and not to the height of the highest design point.

24.2.2 *Light hazard*

24.2.2.1 Range and terminal spur distribution pipe sizes. The nominal size of range pipe and terminal distribution pipes, i.e. distribution pipes downstream of the design point, shall be as given in table 54.

COMMENTARY AND RECOMMENDATIONS ON 24.2.2.1.

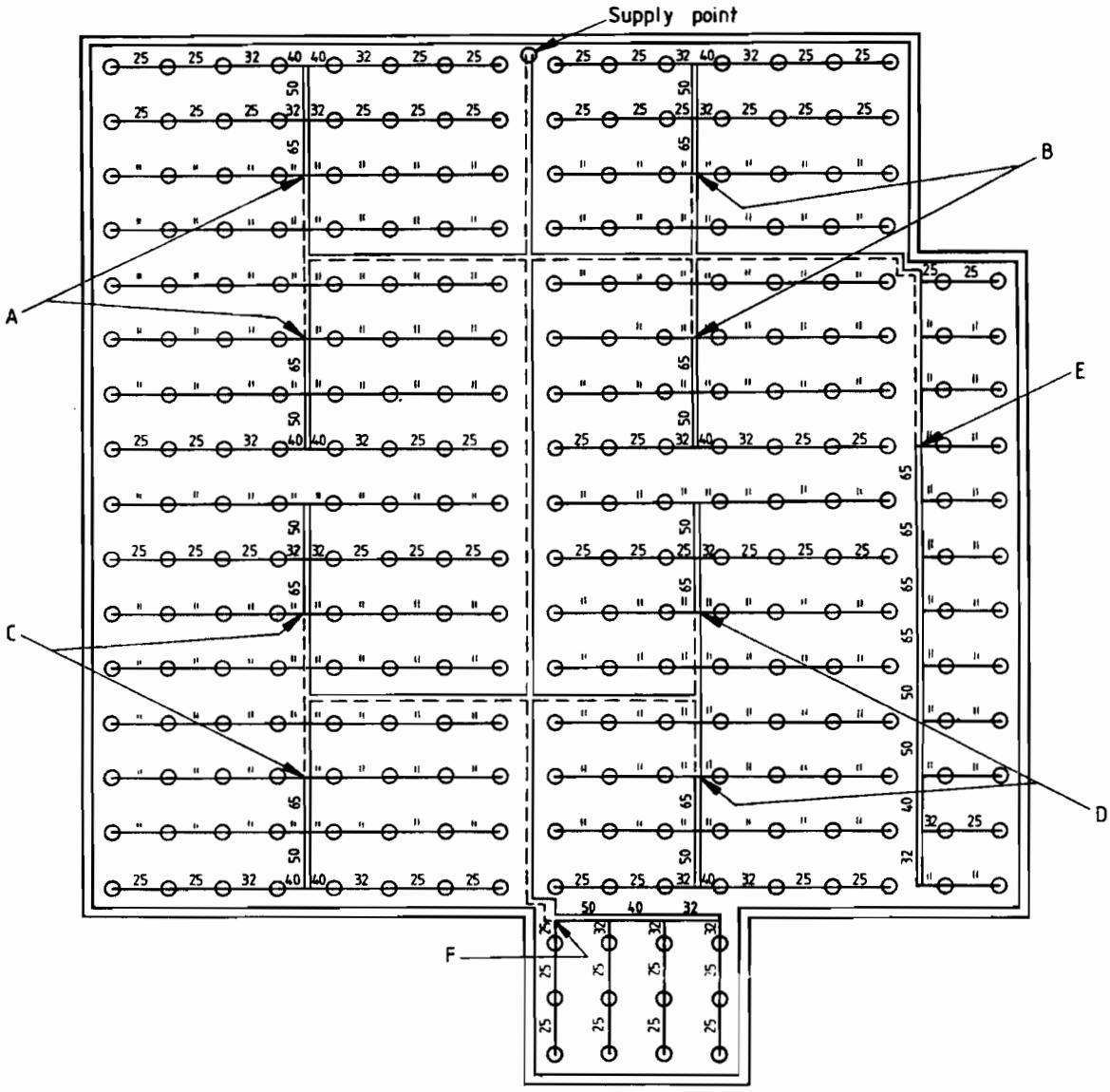
Light-hazard installations differ from ordinary- or high-hazard installations in that sprinklers may be fed directly from distribution pipes (see figure 28).

24.2.2.2 *Distribution pipe (except terminal spurs).* All pipework between the installation main control valves and the design point at each extremity of an installation array at the highest level shall be sized by hydraulic calculation using the values of tables 55 and 56.

The design point shall be the two sprinkler point, except where a range carries four or more sprinklers and either runs along the apex of a ridge roof or is the only line along a narrow room or corridor, in which case it shall be the three sprinkler point.

Where there are more than two sprinklers on any range pipe the pressure loss between the two sprinkler point and the entry point from the distribution pipe to the range shall be calculated using column A of table 56. The loss of pressure in distribution pipework between the point of entry to the range pipe at the extremity of the installation and the installation main control valve set shall be calculated using column B of table 56.

Where the sprinkler arrays in an installation are at different levels the specified maximum total pressure loss between the control valve 'C' gauge and a design point lower than the highest design point shall be increased by the difference in static pressure between that particular design point and the highest design point, subject to the distribution pipe nominal pipe bore being not less than the minimum nominal pipe bore specified in table 54 for the range pipe fed from the design point.



Key:

Range pipe

Distribution pipe (precalculated ≤ 65 mm)

Distribution pipe (hydraulically calculated for maximum loss 0.5 bar between supply point and each design point).

NOTE 1. Pipe sizes are in mm.

NOTE 2. There are 276 sprinklers spaced on a 3.46 m square grid (one per 12 m^2). The hydraulic lengths between the supply point and design points are approximately as follows:

A: 46 m;
B: 43 m;
C: 64 m;
D: 71 m;
E: 69 m;
F: 72 m.

The maximum size of distribution pipe is 100 mm; valves are 100 mm.

Figure 29. Example of application of design points in an ordinary-hazard installation

Table 54. Light-hazard range pipe and terminal distribution pipe sizes

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

*Including allowance for changes of direction (see table 56).

†No elbows fitted; 500 mm if one elbow fitted.

‡The limit of three sprinklers does not preclude the use of 25 mm nominal bore steel or 28 mm copper pipe between the 2/3 sprinkler design point and the installation control valves if hydraulic calculation shows this to be possible, nor does it follow that 25 mm steel or 22 mm copper pipe may be used between the 3rd and 4th sprinklers where the two sprinkler point is the design point.

Table 56. Pressure loss per unit length of pipe for design flow rates in light-hazard installations

Pipe type	Nominal size	Pressure loss/unit length	
		Column A	Column B
	mm	mbar/m	mbar/m
Steel complying with BS 1387 Medium grade	20	135	606
	25	44	200
	32	12	51
	40	5.5	25
	50	1.7	7.8
	65	0.49	2.2
Copper complying with table X of BS 2871 : Part 1 : 1971	15	976	4381
	22	142	638
	28	40.1	179
	35	13.8	62
	42	5.3	25
	54	1.5	6.6
	76	0.27	1.2

NOTE 1. The equivalent length of an elbow, bend or tee where the water is turned through an angle shell be taken as 2 m in using the table or in using clause 18 data.

NOTE 2. Where heavy grade steel tube complying with BS 1387 is used calculate the pressure loss from the data in clause 18 using a flow rate of 100 L/min in place of column A and 225 L/min in place of column B.

Table 55. Maximum pipe flow loss between installation control valve set and each design point in light-hazard installations

Design point	Maximum friction loss including changes of direction	Range and distribution pipe loss
	bar	
Two sprinkler point	0.9	See columns A and B of table 56
Three sprinkler point	0.7	See column B of table 56
Two sprinkler point in narrow room or range at roof apex each with single line of three sprinklers	0.7	See column B of table 56

Table 57. Range pipe nominal sizes for various pipe layouts in ordinary-hazard installations

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

24.2.3 *Ordinary hazard*

24.2.3.1 *Range pipe and terminal distribution pipe sizes.* Range pipe nominal bores shall be as given in table 57.

A single sprinkler shall be fed by pipe of not less than 25 mm nominal bore.

There shall be not more than six sprinklers on any range pipe, including the apex range, where the ranges run longitudinally under a roof sloping at an angle greater than 6 °.

Precalculated distribution pipe nominal bores downstream of the design point shall comply with table 58.

24.2.3.2 *Distribution pipe (except terminal pipe).* The main distribution and distribution pipes (including all risers and drops), between

in low-rise installations, the highest design point in the installation and the sprinkler installation main control valve set, or

in high-rise installations, the highest design point in each zone and the zone subsidiary stop valve at the same floor valve

shall be sized by hydraulic calculation based on the values of table 59. The maximum friction loss shall not exceed 0.5 bar at a flow rate of 1000 L/min.

The feed pipe for all other design points (secondary design points) in the installation shall be similarly sized by hydraulic calculation. The friction loss in any part of the feed pipe not common with that feeding the highest design point (referred to in the previous paragraph) may be increased by not more than the pressure equivalent of the height between the design point under consideration and the highest design point.

The design point shall be the 16 sprinkler point for two end-side sprinkler range pipe layouts and the 18 sprinkler point for all other layouts.

Where the sprinkler arrays in an installation are at different levels the specified maximum total pressure loss between the control valve 'C' gauge and a design point lower than the highest design point shall be increased by the difference in static pressure between that particular design point and the highest design point, subject to the distribution pipe nominal pipe bore being not less than the minimum nominal pipe bore specified in table 58 for the range pipe fed from the design point.

Table 58. Distribution pipe nominal sizes in ordinary-hazard installations, and maximum number of sprinklers downstream of design point

Pipe layout	Distribution pipe nominal size	Maximum number of sprinklers to be fed by pipe of size listed
	mm	
(a) Two end-side layout	32	2
	40	4
	50	8
	65*	16*
(b) All other layouts	32	3
	40	6
	50	9
	65*	18*

*This does not preclude the use of 65 mm nominal bore pipe between the 16/18 sprinkler point and the installation main control valves if it complies with the hydraulic calculation requirements (see **24.2.3.2**).

Table 59. Pressure loss per unit length of pipe for design flow rates in ordinary-hazard installations

Pipe nominal bore (BS 1387: Medium grade)	Pressure loss per unit length
mm	mbar/m
65	35
80	16
100	4.4
150	0.65
200	0.16

NOTE 1. The equivalent length of an elbow, bend or tee where the water is turned through an angle shall be taken as 3 m when using the table or clause **18** data.

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

COMMENTARY AND RECOMMENDATIONS ON 24.2.3.2.

The 65 mm *minimum nominal diameter feed pipe limitation, and the requirement that pipes may only diminish in size in the direction of water flow to the sprinklers, may result in the feed pipe friction loss being less than* 0.5 bar *plus any static pressure gain.*

Where feed pipe losses are calculated as specified for a secondary design point the pipe friction in the feed pipe from the valves to the secondary design point will be not more than 0.5 bar *plus the static head difference between that design point and the highest design point in the installation.*

Indication of the highest sprinkler above the datum point, and details of the hydraulically most remote design point, are given on the wall-mounted block plan (see 29.1).

24.2.4 *High hazard*

24.2.4.1 *Range pipe and terminal distribution pipe sizes.* Range pipe nominal bores shall be as given in table 60 or 61 depending upon the sprinkler nominal size and the table in which the water supply pressure-flow characteristic is specified (i.e. tables 16, 17, 18 or 19).

No range pipe shall connect to a distribution pipe exceeding 150 mm nominal bore.

Precalculated distribution pipe nominal bores downstream of the design point shall be as given in table 62 or 63 depending upon the sprinkler head nominal size and the table in which the water supply pressure-flow characteristic is specified (i.e. tables 16, 17, 18 or 19).

24.2.4.2 *Distribution pipe upstream of the design point.* The main distribution and distribution pipes between each sprinkler design point and the main installation control valve set shall be sized by hydraulic calculation using the pipe friction loss per unit length given in table 64 for the flow specified in **15.2.3.**

The design point shall be the 48 sprinkler point or if appropriate as specified in **15.2.3, 15.2.4** or **24.2.1.4.**

The highest sprinkler shall be either downstream of a sprinkler design point or in an array with its own terminating distribution spur.

The pressure loss in the distribution pipe to any particular section of the installation shall be adjusted to that needed to match the water supply characteristic by either:

(a) suitably sizing the distribution pipe spur feeding the particular section when the distribution pipe nominal size shall not be less than that of the first length, sized by the pipe tables, of distribution pipe downstream of the design point to which it is connected, or

(b) fitting an orifice plate complying with **24.1.3** in the particular distribution pipe (see figures 30 to 32).

Table 60. Range pipe nominal sizes for various pipe layouts, for high-hazard installations with sprinklers of 15 mm nominal size and pressure-flow characteristics as given in table 16 or table 17

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

Table 61. Range pipe nominal sizes for various pipe layouts, in high-hazard installations with sprinklers of 15 mm nominal size and pressure-flow characteristics as given in table 18, or of 20 mm nominal size and pressure-flow characteristics as given in table 19

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

Table 62. Distribution pipe nominal sizes feeding various numbers of sprinklers downstream of the design point, in high-hazard installations with sprinklers of 15 mm nominal size and pressure-flow characteristics as given in table 16

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

*This does not preclude the use of 100 mm nominal size pipe between the design point and the installation main control valves if it complies with the hydraulic calculation requirements (see **24.2.4.2**).

Table 63. Distribution pipe nominal sizes feeding various numbers of sprinklers downstream of the design point in high-hazard installations with sprinklers of 15 mm nominal size and pressure-flow characteristics as given in table 17 or table 18, or sprinklers of 20 mm nominal size and pressure-flow characteristics as given in table 19

Range pipe layout	Distribution pipe nominal size	Maximum number of sprinklers to be fed by pipe of size listed
	mm	
Four end-side	65	8
All other layouts	50	4
	65	8
	80	12
	100	16
	150	48*

*This does not preclude the use of 150 mm nominal size pipe between the design point and the installation main control valves if it complies with hydraulic calculation requirements (see **24.2.4.2**).

24.3 Fully hydraulically calculated pipe arrays

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

COMMENTARY AND RECOMMENDATIONS ON 24.3.1.
Any pipe layout may be used subject to the sprinkler spacing and location requirements of this clause and clause 26.

24.3.2 *Minimum pipe sizes.* The nominal bore of main and other distribution pipes, and range pipes shall be not less than as follows:

(a) in a light-hazard installation	20 mm (steel), or 22 mm (copper), or as given in table 54 for single sprinklers
(b) in an ordinary or high-hazard installation	25 mm

24.3.3 *Maximum range pipe size.* The nominal bore of range pipes shall be not more than 65 mm, except where individual sprinklers are connected to pipes exceeding 65 mm nominal bore when the arrangement shall comply with **24.1.2.**

24.3.4 *Density of discharge.* The minimum density of discharge from each AMAO, or the entire protected area, whichever is the smaller, containing the relevant group of four sprinklers with each water supply or supply combination available shall be not less than the design density specified in clause **14.**

Where possible the density of discharge shall be taken as the total flow from a group of four sprinklers which are most closely adjacent (in standard layout four sprinklers lying on the corners of a matrix cell square or rectangle, or in a staggered layout four sprinklers on the corners of a notional parallelogram), in L/min divided by four times the area (in m^2) of the notional square, rectangle or parallelogram on the corners of which the sprinklers lie. Where fewer than four sprinklers are in open communication, the minimum density shall be taken as the lowest value of the flow from any sprinkler divided by the area covered by the sprinkler. The area covered shall be taken as that defined by the centre 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 33).

COMMENTARY AND RECOMMENDATIONS ON 24.3.4. *Where the boundary is irregular the nearby sprinkler layout is also irregular, the density of discharge should be taken as the flow from four sprinklers, divided by the sum of the areas (see 24.3.6.3) covered by each sprinkler.*

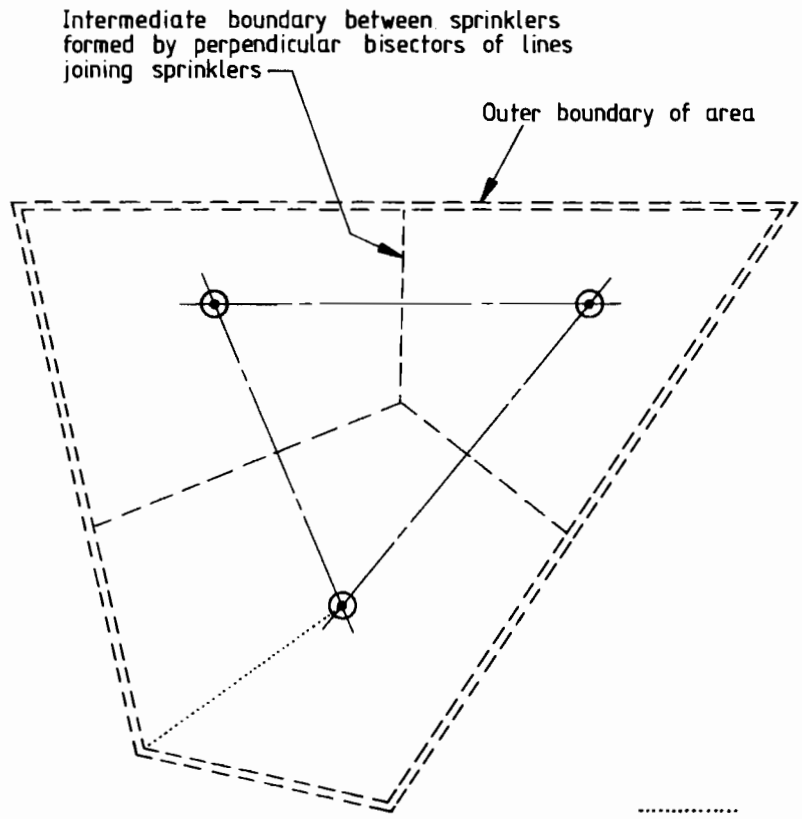


Figure 33. Area covered by individual sprinklers where less than four sprinklers are in open communication

Table 64. Pressure loss per unit length of pipe for design flow rates in high-hazard installations

Flow rate	Pressure loss per unit length			
	100 mm nominal size Medium grade pipe complying with BS 1387	150 mm nominal size Medium grade pipe complying with BS 3601	200 mm nominal size 5.4 mm wall complying with BS 3601	250 mm nominal size 7.1 mm wall complying with BS 3601
L/min	mbar/m	mbar/m	mbar/m	mbar/m
1000	4.4	0.65	0.16	0.054
1500	9.3	1.4	0.35	0.12
2000	16	2.4	0.59	0.20
2300	21	3.0	0.76	0.25
3050	34	5.1	1.3	0.43
3800	52	7.7	1.9	0.64
4550	72	11	2.7	0.90
4850	82	12	3.0	1.0
6400	140	20	5.1	1.7
7200	170	25	6.3	2.1
8000	210	31	7.7	2.6
8800	250	36	9.1	3.0
9650	290	43	11	3.6

NOTE 1. Values may be interpolated.

Where another grade of pipe is used calculate the pressure loss from the data in clause **18** using the appropriate flow rate.

NOTE 2. The equivalent length of an elbow, bend or tee where the water is turned through an angle shall be taken as 3 m when using the table or clause **18** data.

24.3.5 *Minimum sprinkler flow pressure.* The calculated discharge pressure at roof or ceiling sprinkler, or an intermediate sprinkler, other than a rack or shelf sprinkler, when all the sprinklers in an AMAO plus the required number of any intermediate sprinklers are discharging simultaneously, and the predicted pressure at the 'C' gauge is available from the supply, shall be not less than as given in table 65.

COMMENTARY AND RECOMMENDATIONS ON 24.3.5. *Note that the predicted pressure at the 'C' gauge in the case of a town main is only a proportion of that actually available (see 17.1.1.4). Where there are pumped supplies the requirements of 17.4.6.4 may affect the pump pressure rating.*

Note that where there are sprinklers at levels other than that of the roof or ceiling (i.e. in racks), simultaneous operation of AMAOs may be specified (see clause 14) and the design density is to be achieved by each relevant AMAO simultaneously.

See 14.6.3 for the relative positions of AMAOs for roof or ceiling sprinklers and intermediate sprinklers.

See 14.6.2 for intermediate level rack or shelf sprinkler pressures, which are higher than those given in table 65.

Table 65. Minimum sprinkler discharge pressure for non-rack sprinklers in fully hydraulically calculated installations

Hazard class	Minimum pressure at any discharging sprinkler
	bar
Light	0.7
Ordinary	0.35
High	0.5

24.3.6 *Number of sprinklers in AMAO*

24.3.6.1 *AMAO.* The AMAO shall be either:

(a) as specified for each layout in clause **14**; or

(b) the area in open communication (i.e. where sprinklers may be expected to operate during the same fire incident) of the hazard class concerned;

whichever is the smaller.

Where different hazard classes are in adjacent areas and in open communication the AMAO of the highest class shall apply and any excess area specified in clause **14** shall be assumed to be in operation in the hydraulically least favourable position in an adjacent part of the lesser hazard area.

Where the total area in open communication is less than the AMAO specified in clause **14**, the whole area shall be assumed to be in simultaneous operation.

COMMENTARY AND RECOMMENDATIONS ON 24.3.6.1. *It is essential that the lower-hazard area operates with its own appropriate AMAO contained wholly within it, or with the total area in operation where this is less.*

24.3.6.2 *Number of sprinklers in AMAO.* The number of sprinklers in simultaneous operation shall be integral and not less than N, given by the equation:

$$N = \frac{A}{a} + R$$

where

A is the roof or ceiling sprinkler AMAO (in m^2);

a is the mean floor area covered by each roof or ceiling sprinkler in the AMAO under consideration (in m^2);

R is the number of sprinklers located under obstructions in the area of operation.

COMMENTARY AND RECOMMENDATIONS ON 24.3.6.2. *See 26.8 for sprinkler under extensive platforms, when it may be necessary to include the roof/ceiling sprinklers in the hydraulic calculations relating to the platform sprinklers.*

24.3.6.3 *Area covered by individual sprinkler.* In a square or rectangular matrix array the area covered by an individual sprinkler not on the boundary of the array shall be the floor area contained by a notional square or rectangle formed by the two centre lines between the sprinkler and the two adjacent sprinklers on the range, and the two centre lines between the range pipe carrying the sprinkler and the two adjacent range pipes (see figure 34(a)).

In a staggered array the area covered by an individual sprinkler shall be that of the floor area contained by a notional parallelogram formed by the centre lines between the range pipe carrying the sprinkler and the two adjacent range pipes and the lines joining points on the range pipe sections midway between the sprinkler and each of the two adjacent sprinklers on the range and the corresponding positions on the two adjacent ranges (see figure 34(b)).

COMMENTARY AND RECOMMENDATIONS ON 24.3.6.3. *Where a sprinkler is on the boundary of the area concerned, the area covered between it and the adjacent sprinklers away from the boundary should be calculated using 24.3.6.3, and the area covered on the boundary side of the sprinkler determined using the layout plan by the following procedure:*

(a) draw lines joining the sprinklers along the boundary;

(b) draw perpendicular to the lines, from the mid-point of each of the lines between adjacent sprinklers, to the boundary;

(c) measure the area between the boundary, the projected centre lines and the lines joining the sprinkler to the adjacent pair of boundary sprinklers.

This area added to the area (calculated as specified in 24.3.6.3) between the sprinkler and those further from the boundary is the area covered by the sprinkler.

Where sprinklers adjacent to irregular boundary sprinklers are as a result irregularly spaced, and also where as a result the number of sprinklers per range pipe varies, the procedure shown in figure 34 may be adopted to establish the area per sprinkler.

24.3.7 *Locations of AMAO*

24.3.7.1 *Hydraulically most unfavourable location.* Changes in sprinkler spacing, array design, elevation, range centres, sprinkler nominal orifice size and pipe sizes, as well as all possible locations, whether on the distribution pipes or between distribution pipes where these are connected by range pipes, shall be considered when determining the hydraulically most unfavourable location of the AMAO.

COMMENTARY AND RECOMMENDATIONS ON 24.3.7.1. *Full calculation for each possible location is necessary except where it is obvious that an array is similar to another array under consideration and is hydraulically nearer the water supply.*

24.3.7.2 *Hydraulically most favourable location.* All possible locations, whether on the distribution pipes, or between distribution pipes where these are connected by ranges, shall be considered for the hydraulically most favourable location of the AMAO.

COMMENTARY AND RECOMMENDATIONS ON 24.3.7. *See the commentary and recommendations on 24.3.5.*

Continuous operation of the maximum AMAO or AMAOs at the relevant hydraulically most unfavourable locations creates the most adverse pressure condition. This is used to establish that the minimum sprinkler discharge pressure and the required density averaged over any four adjacent sprinklers are achieved (see 24.3.4).

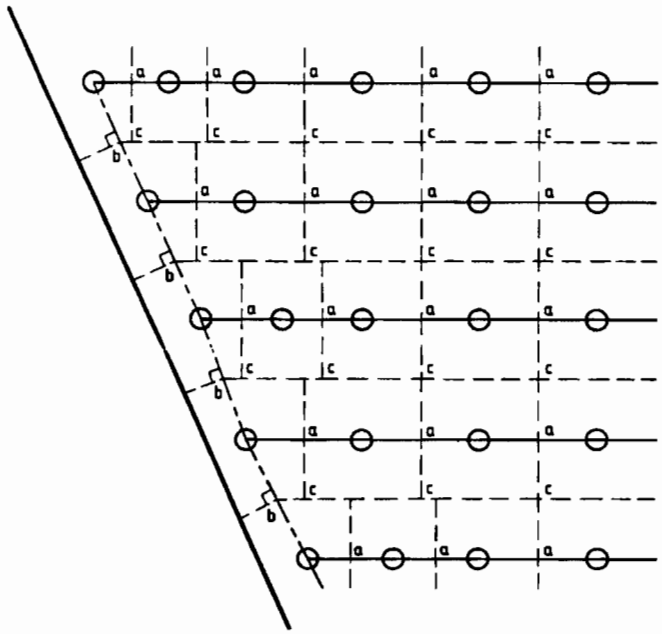
Continuous operation of the AMAO or AMAOs at the hydraulically most favourable location(s) in the installation gives the flow rate which is used to determine that the design is compatible with the water supply pressure-flow characteristic(s).

Proof of the correct position of the hydraulically most favourable AMAOs in the case of gridded installations entails displacing the area of operation by one sprinkler pitch in each direction along ranges and by one range pipe in each direction along distribution pipes. In any layout it may be necessary to examine other possible locations because of sloping range effects, changes of sprinkler pitch or range spacing, changes of sprinkler elevation or orifice size, change of range pipe size or irregular layout owing to building constraints.

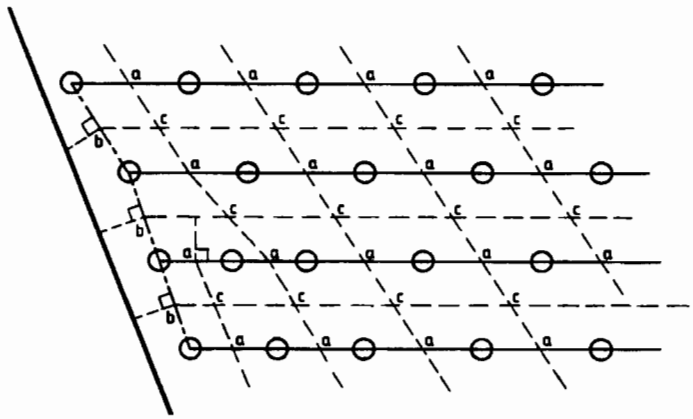
24.3.8 *Shape of AMAO*

24.3.8.1 *Hydraulically most unfavourable location.* The following shall be considered.

(a) *Terminal spur and looped distribution pipe installations with spur ranges.* In the hydraulically most



(a) standard layout



(b) staggered layout

Key:

		———	zone boundary line
⊔	right angle	———	range pipe
a	mid-point along range pipe	– – –	intermediate boundary line (between areas covered by adjacent sprinklers)
b	mid-point between sprinklers	—·—	drawing construction line
c	mid-point between ranges	—○—	sprinkler

Figure 34. Area covered by individual sprinklers (large arrays)

unfavourable location the shape of the maximum AMAO shall be as near as possible rectangular. One side shall be defined by the range, or range pair where there is an end-centre arrangement.

Sprinklers not constituting a full range or range pair shall be grouped as close as possible to the distribution pipe on the next upstream range row to the rectangular area (see figures 35 and 36).

(b) *Gridded installations.* Where ranges run parallel to the ridge of a roof which has a slope greater than 6 °, or along bays formed by beams greater than 1.0 m deep, the shape of the AMAO for the hydraulically most unfavourable location shall be rectangular with a length (L) greater than or equal to twice the square root of its area, i.e.:

$$L \geqslant 2 \times A^{1/2}$$

In all other cases the shape of the AMAO shall be rectangular with a length (L) greater than or equal to 1.2 times the square root of its area, i.e.:

$$L \geqslant 1.2 \times A^{1/2}$$

where

L is dimension of area parallel to range pipes (in m);

A is AMAO (in m^2).

both measured in the horizontal plane.

The AMAO shall be either symmetrical with respect to the sprinkler layout matrix; or substantially symmetrical with any sprinklers not forming a full range length grouped on the more favourably placed adjacent range at the hydraulically most favourable end of the area (see figure 37).

24.3.8.2 *Hydraulically most favourable location.* The following shall be considered.

(a) *Terminal spur and looped distribution pipe installations with spur ranges.* In the hydraulically most favourable location the shape of the AMAO shall be as near as possible square, and shall where possible comprise sprinklers on one distribution pipe only. The number of sprinklers calculated to be operating on ranges, or range pairs in end-centre installations, shall be located on each range or range pair at the hydraulically most favourable location. Sprinklers not constituting a full range or range pair shall be located on the next range row at the hydraulically closest locations (see figures 35 and 36).

(b) *Gridded installations.* The AMAO shall be as nearly as possible square and located equidistant from contained lines of sprinklers on each opposite side.

The number of sprinklers calculated to be operating shall be located on ranges at the hydraulically most favourable location, with any sprinklers to make up the AMAO, as in (a) above, located on the next range row at the hydraulically closest locations (see figure 37).

COMMENTARY AND RECOMMENDATIONS ON 24.3. *See clause 18 and subclauses headed 'Fully hydraulically calculated installations' in other relevant clauses. The requirements of 24.3.2 may also be applied to deluge installations.*

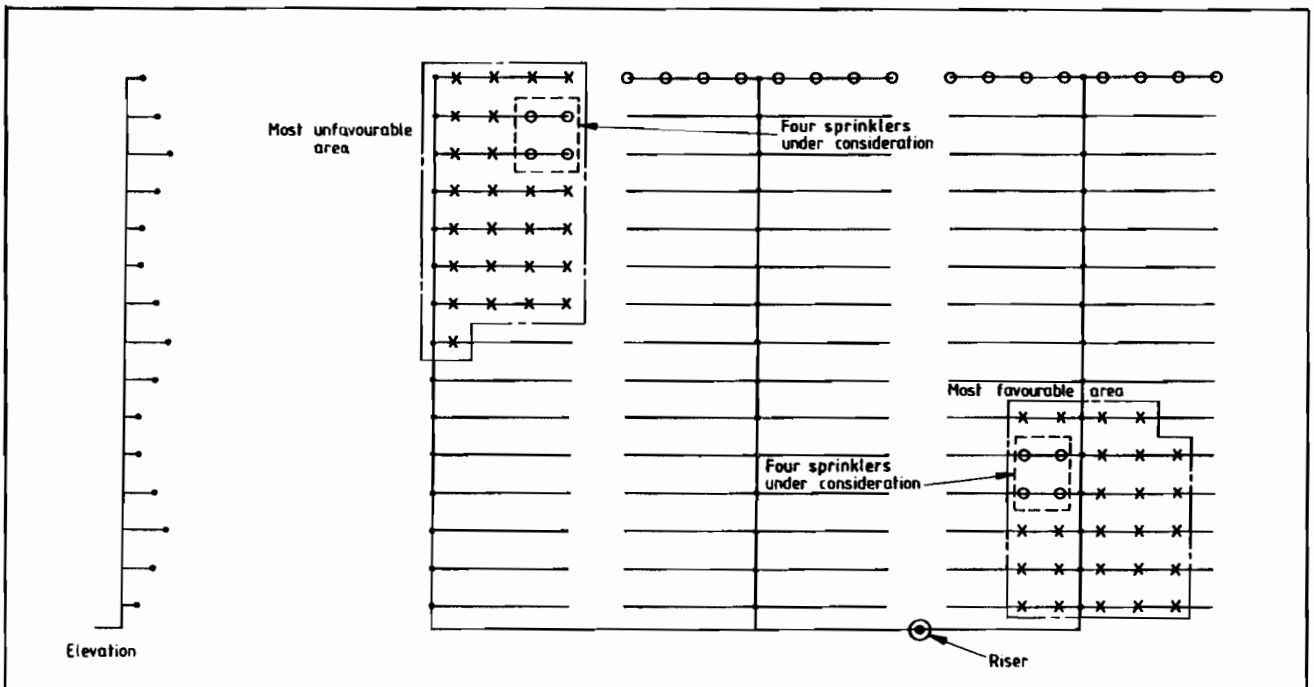


Figure 35. Typical hydraulically most favourable/unfavourable locations of AMAO in an installation with terminal main distribution piping

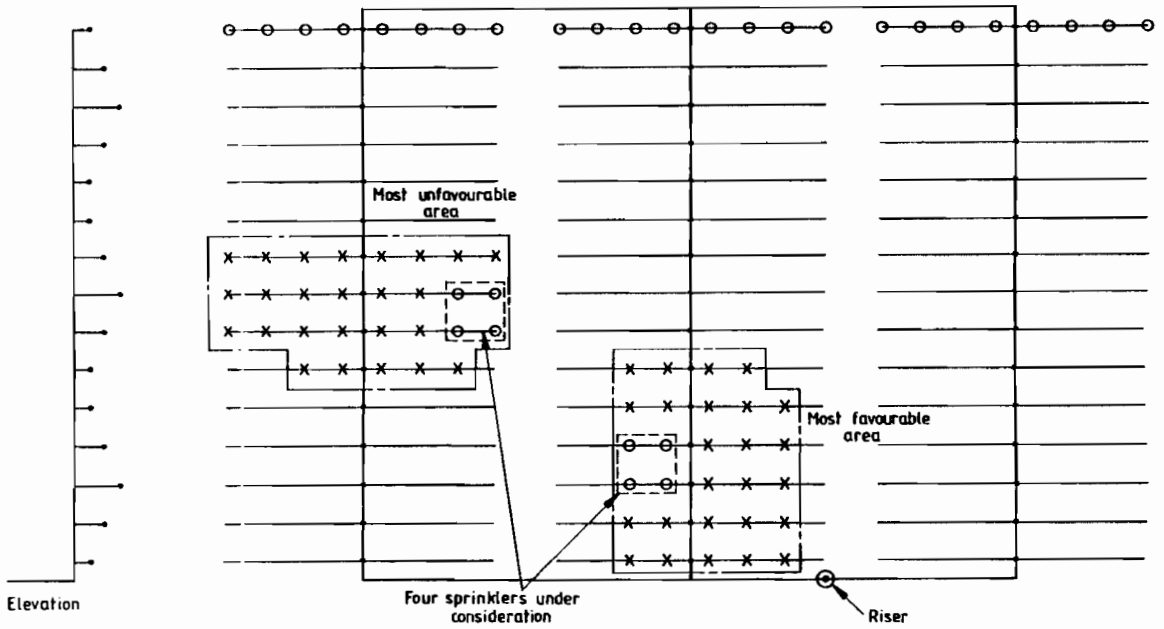


Figure 36. Typical hydraulically most favourable/unfavourable locations of AMAO in an installation with looped distribution piping

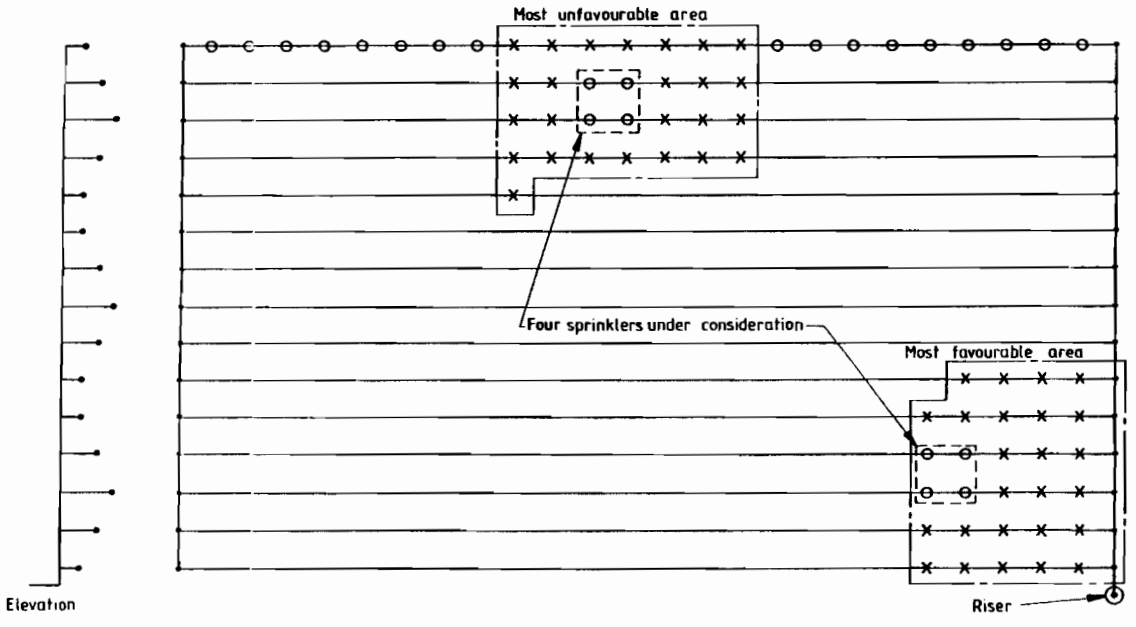


Figure 37. Typical hydraulically most favourable/unfavourable locations of AMAO in an installation with gridded piping

25 Sprinkler, multiple control and sprayer design characteristics and uses

25.1 General

Sprinklers, multiple controls, sealed or unsealed medium-velocity sprayers and high-velocity sprayers installed in sprinkler installations shall be suitable for fire protection service.

Only new sprinkler and medium-velocity sprayers shall be used. Multiple controls shall be either new or reconditioned and pressure tested by the original manufacturer.

Sprinkler heads, multiple controls and medium- or high-velocity sprayers shall not be painted except for identification purposes. They shall not be altered in any respect nor have any type of ornamentation or coating (other than as specified in **25.11**) applied after despatch from the production factory.

25.2 Sprinkler types and applications

25.2.1 *Types.* Sprinklers shall be of the following types:

(a) conventional pattern (see **2.65**);

(b) spray pattern (see **2.77**);

(c) ceiling or flush pattern (see **2.63**);

(d) recessed pattern (see **2.74**);

(e) concealed pattern (see **2.64**);

(f) sidewall pattern (see **2.76**).

25.2.2 *Applications.* Sprinklers shall be selected for use in accordance with table 66, and as specified in **25.2.3**, **25.2.4** and **25.2.5**.

COMMENTARY AND RECOMMENDATIONS ON 25.2.2.
Conventional pattern sprinklers may be installed as needed under roofs, ceilings, platforms, shelves, etc. and in racks and concealed spaces.

25.2.3 *Spray pattern.* Spray pattern sprinklers shall not be used as follows:

(a) in high-hazard, high-piled storage applications; or

(b) as roof or ceiling sprinklers in ordinary- or high-hazard applications where there is exposed structural steelwork or where the roof or ceiling or its support structure is of combustible material.

25.2.4 *Ceiling or flush, recessed and concealed pattern.* Ceiling or flush, recessed and concealed sprinklers shall be installed only in light- or ordinary-hazard areas.

Those sprinklers without fixed deflectors, that is with retracted deflectors that drop to the normal position on actuation, shall not be fitted as follows:

(a) where the ceiling is more than 45 ° from the horizontal; or

(b) in situations where the atmosphere is corrosive or liable to have a high dust content; or

(c) in racks or under shelves.

Table 66. Sprinkler types and sizes for various hazard classes

Hazard class and sprinkler location	Pattern of sprinkler	Sprinkler nominal orifice size	
		Precalculated installations	Fully hydraulically calculated installations
		mm	mm
Light hazard	Any	10	10
Ordinary hazard	Conventional Spray Ceiling or flush Recessed Concealed	15	10 or 15
	Sidewall	15	15
High hazard Ceiling or roof sprinklers	Conventional or spray	15 or 20	15 or 20
High hazard Intermediate sprinklers in piled storage	Conventional	–	15

COMMENTARY AND RECOMMENDATIONS ON 25.2.4. *Typical applications are hotel lobbies and dining rooms, offices, boardrooms, and parts of retail stores. Ceiling or flush sprinklers and concealed pattern sprinklers may respond more slowly than conventional or spray pattern sprinklers.*

25.2.5 *Sidewall pattern.* Sidewall sprinklers shall not be installed in high-hazard applications or above suspended ceilings.

COMMENTARY AND RECOMMENDATIONS ON 25.2.5. *Sidewall pattern sprinklers may be used under flat ceilings or roofs as a substitute for conventional or spray pattern sprinklers in offices, entrance halls, shop windows, lobbies, corridors, etc; or where condensate from centrally installed pipework and sprinklers might drip onto product below, e.g. in drying ovens and under hoods over papermaking machines; or under platforms, etc. where headroom is low.*

25.3 Multiple controls

The temperature-sensitive element of a multiple control shall have one of the temperature ratings given in table 67 or table 68.

Table 67. Fusible link sprinkler ratings and colour code

Temperature rating	Colour of yoke arms
°C	
57/77	Natural (uncoloured)
80/107	White
121/141	Blue
163/191	Red
204/246	Green
260/302	Orange
320/343	Black

Table 68. Glass bulb sprinkler temperature ratings and colour code

Temperature rating	Colour of bulb liquid
°C	
57	Orange
68	Red
79	Yellow
93	Green
141	Blue
182	Mauve
227/260	Black

25.4 Medium- and high-velocity sprayers

25.4.1 *Medium-velocity sprayer.* A medium-velocity sprayer of the sealed type shall be of one of the temperature ratings, and shall be appropriately colour coded, as given in table 67 or table 68.

25.4.2 *High-velocity sprayer.* A high-velocity sprayer shall be of the open (unsealed) type. Any means employed to prevent ingress of foreign matter into the nozzle shall be removable without detriment to the water spray discharge pattern by the commencement of water discharge, and shall be fitted in the manufacturer's works and shall be suitable for sprinkler use.

25.5 Sprinkler size and k factor

25.5.1 *Sprinkler nominal orifice size.* A sprinkler shall have a nominal orifice size of 10 mm, 15 mm or 20 mm, and the k factor shall be as given in table 69.

COMMENTARY AND RECOMMENDATIONS ON 25.5.1. *The orifice size* (in mm) *is marked on the body or deflector of the sprinkler (see 31.6).*

The k factor is given by the formula:

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

where

Q = *the flow through the sprinkler orifice (in* L/min*);*

P = *the pressure at entry to the sprinkler shank or in the case of pendent or upright dry sprinklers at the entry to the drop or rise pipe (in* bar*).*

25.5.2 *Shank thread.* The shank thread nominal size shall be related to the nominal orifice size as given in table 69.

COMMENTARY AND RECOMMENDATIONS ON 25.5.2. *This prevents inadvertent interchange between sprinklers of different orifice size and water flow performance when replacing sprinklers in an installation.*

25.5.3 *Water flow calculations.* The water flow through a sprinkler shall be calculated from:

$$Q = k\sqrt{P}$$

using the mean value, given in table 69, of the k factor.

COMMENTARY AND RECOMMENDATIONS ON 25.5.3. *For dry sprinklers (pendent or upright) the k factor inludes the friction loss in the drop or rise pipe of the unit. However the static head gain or loss in the drop or rise pipe respectively has to be allowed for in the calculation.*

25.6 Temperature ratings and colour coding

Sprinklers shall have one of the temperature ratings given in table 67 or table 68 and shall be correspondingly colour coded.

Table 69. Sprinkler nominal threads, orifice sizes and k factors

Sprinkler nominal orifice size	Sprinkler nominal thread size	Mean value of k factor	Limiting values of k factor			
			Dry sprinklers		All other sprinklers	
			Not less than	Not more than	Not less than	Not more than
mm	mm					
10	10	57	52	62	54	60
15	15	80	74	86	76	84
20	20	115	106	124	109	121

25.7 Selection of temperature rating

25.7.1 *General.* The temperature rating of a sprinkler shall be not less than 30 °C greater than the highest expected ambient temperature of the location.

COMMENTARY AND RECOMMENDATIONS ON 25.7.1.
For normal conditions in temperate climates sprinkler temperature ratings of 68/74 °C *should be installed. Unventilated concealed spaces and unventilated shop or show windows should be given special consideration; the sprinkler temperature rating may need to be higher than elsewhere in the premises.*

25.7.2 *High-piled storage hazards with intermediate sprinklers.* In high-hazard installations protecting high-piled storage with intermediate sprinklers, the roof or ceiling sprinklers shall have a temperature rating of 141 °C.

COMMENTARY AND RECOMMENDATIONS ON 25.7.2.
Intermediate sprinklers within or at the top of racks (palletized or shelved) should be rated in accordance with ambient temperature and not at 141 °C *as specified for the roof or ceiling sprinklers.*

25.7.3 *Glazed roofs and plastics roof lights.* Under glazed roofs or where there are roof lights of PVC, or similar plastics material, the sprinkler rating shall be either 79 °C to 100 °C, or 141 °C for high-piled storage.

COMMENTARY AND RECOMMENDATIONS ON 25.7.3. *Solar heating may cause high ambient temperatures.*

See 26.9.4 for restrictions on sprinkler protection under plastics roof lights.

25.7.4 *Drying ovens and hot process ventilating hoods.* The temperature rating of roof or ceiling sprinklers within 3 m of the plan area of the boundary of either an oven or a hot process ventilating hood, fitted with sprinklers, shall be the same as the oven or hood sprinklers, or 141 °C, whichever is the lower.

25.8 Sprinkler guards

Any sprinkler, other than ceiling or flush sprinkler, installed in a position at risk of accidental damage shall be fitted with a metal guard suitable for sprinkler service.

COMMENTARY AND RECOMMENDATIONS ON 25.8. *It is particularly important in cold stores and in racks to ensure that sprinklers are installed in positions where there is no likelihood of mechanical damage through movements of goods.*

25.9 Sprinkler water shields

A sprinkler installed in a rack or under a perforated shelf, platform or the like, where water from a higher sprinkler or sprinklers (including roof or ceiling sprinklers) may cause wetting in close proximity to the bulb or fusible element, shall be fitted with a metal water shield of nominal diameter 75 mm.

The water shield shall not be attached directly to an upright sprinkler deflector or yoke assembly. Any bracket support shall form a minimal obstruction to the sprinkler water distribution.

25.10 Sprinkler rosettes

Sprinkler rosettes shall be of metal or thermosetting plastics material and shall be suitable for sprinkler service.

Rosettes shall not be used to support ceilings or other structures.

No part of a rosette shall project from the ceiling below the top of the visible portion of the heat-sensitive element.

25.11 Corrosion-protection of sprinklers and multiple controls

Sprinklers and multiple controls used in premises identified in (b) and (c) of the commentary and recommendations to **5.5** or elsewhere where corrosive vapours are prevalent shall either:

(a) have corrosion-resistant coatings applied by the manufacturer which are suitable for sprinkler service; or

(b) be coated twice with good-quality petroleum jelly once before and once after installation.

The anti-corrosion treatment shall not be applied to the body of any glass bulb.

25.12 Frost protection of sprinklers

Plastics or paper or other covers shall not be fitted over sprinklers in wet or alternate installation to prevent frost damage.

COMMENTARY AND RECOMMENDATIONS ON 25.12.
The practice of fitting covers over sprinklers as a protection against frost is undesirable as it slows down the operation of the sprinklers, and may impair the distribution of water. Covers may be necessary in hazards such as paint spray booths (see 35.2.3).

26 Sprinkler spacing, arrangement and location

26.1 Maximum spacing between sprinklers and maximum area protected per sprinkler

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

COMMENTARY AND RECOMMENDATIONS ON 26.1.1.
Although the dimensions for sprinkler spacing and area are taken in a horizontal plane, in hydraulic calculations the dimensions are true lengths, measured along the slope of a pipe.

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

COMMENTARY AND RECOMMENDATIONS ON 26.1.2.
Sprinklers are therefore orientated upright or pendent relative not to the horizontal plane but to the roof ceiling or staircase.

26.1.3 *Sprinklers installed under roofs, ceilings and platforms*

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

(a) the slope of the ceiling or roof is greater than 1 in 3 (i.e. is greater than 18½ ° to the horizontal); and

(b) the ranges run parallel to the roof ridge, i.e. the sprinklers are not valley fed, with the axis of the sprinkler positioned vertically;

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

26.1.3.2 Where sprinklers are installed under roofs, ceilings, platforms or similar planar surfaces, the area covered by a sprinkler and the distance between adjacent sprinklers shall be not more than as given in table 70, for non-sidewall sprinklers, or table 71 for sidewall sprinklers, or table 71 and **26.1.3.3** for combinations of sidewall and non-sidewall sprinklers.

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

The boundary of the sidewall sprinkler coverage shall be taken as not more than 3.7 m from, and parallel to, the walls against which the sidewall sprinklers are mounted. The space between the sidewall sprinkler boundaries parallel to the opposite walls is to be protected by the ceiling sprinklers in standard layout (see table 70).

COMMENTARY AND RECOMMENDATIONS ON 26.1.3.
Staggered spacing is used only in ordinary-hazard installations (see table 70 and figure 38) and where sidewall sprinklers are used on either side of a room over certain lengths and widths in light-hazard installations (see table 71).

Where sidewall sprinklers are installed under non-fire resisting ceilings, the spacing along walls is reduced (see table 71).

Figure 39 shows typical sidewall sprinkler layouts.

When an ordinary-hazard installation is to be upgraded to high hazard, using 12 m^2 *maximum coverage area, it is essential that either the installation be fully hydraulically calculated or the correct column of table 16, 17, 18 or 19 be used.*

26.1.4 *Intermediate sprinklers in high-hazard occupancies*

26.1.4.1 *High-hazard intermediate sprinklers in non-shelved racks.* Intermediate sprinklers shall be provided for palletized rack storage and multiple row drive through storage (see type S5 in table 1) as specified in table 72 as follows.

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

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

(c) Double row racks not more than 3.2 m wide centrally in the longitudinal flue space shall be protected by sprinklers, at the stack ends, and at the tier levels specified in table 72.

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

COMMENTARY AND RECOMMENDATIONS ON 26.1.4.1.
Type S5 covers racked storage heights in excess of those in table 1 or where the aisles between stacks are less than 1.2 m *wide, and intermediate sprinklers are specified. See also 5.4.3.*

Table 70. Maximum coverage and maximum spacing for non-sidewall sprinklers

Hazard class	Maximum area coverage per sprinkler (*S* X *D* in figure 38)	Maximum distance between sprinklers			
		Spacing pattern (see figure 38)			
		Standard layout		Staggered layout	
		Along range *'S'* in figure 38	Between ranges *'D'* in figure 38	Along range *'S'* in figure 38	Between ranges *'D'* in figure 38
	m^2	m	m	m	m
Light	21, see note 1	4.6, see note 1	4.6, see note 1	–	–
Ordinary	12, see note 2	4.0, see note 2	4.0, see note 2	4.6, see note 2	4.0, see note 2
High	9, see note 3	3.7	3.7	–	–

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

NOTE 2. In cold storage warehouses using the air circulation method of refrigeration, corn, provender and rice mills not using pneumatic conveying, film and television production studios, the stage areas of theatres and above open suspended ceilings, the area coverage of a sprinkler shall be not more than 9.0 m^2 and the spacing between sprinklers, along and between ranges shall be not more than 3.0 m. See **5.5**, **26.9.1** and **26.9.2**.

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

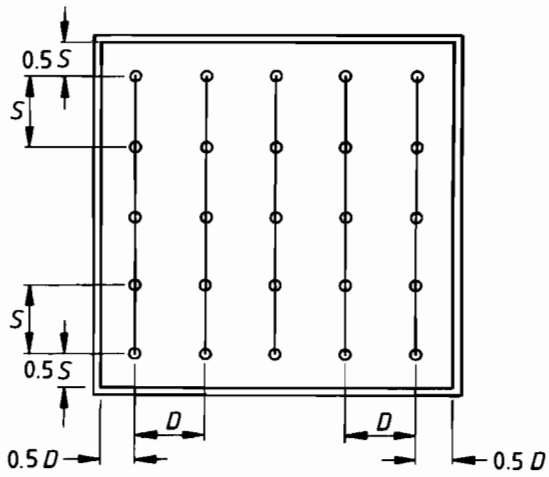
Table 71. Maximum coverage and maximum spacing for sidewall sprinklers

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

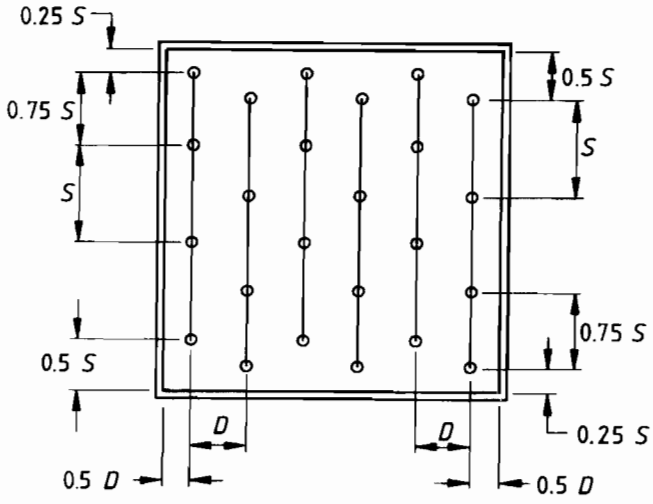
*Additional row or rows of roof or ceiling sprinklers required.

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

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



(a) Standard layout (rectangular matrix)



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

Key:

S is spacing between sprinklers on range pipes
D is spacing between range pipes

All dimensions shown are in metres.

Figure 38. Ceiling sprinkler spacing

26.4 Clear space below sprinklers

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

(a) for high-piled combustible stock (see table 1): 1.0 m;

(b) for potable spirit barrel storage: 0.3 m;

(c) for sprinklers above open suspended ceilings: 0.8 m;

(d) for other than (a), (b) or (c): 0.5 m.

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

26.5 Sprinkler location relative to building structure and plant

26.5.1 *Roofs and ceilings*

26.5.1.1 *Roofs and ceilings, without bays or beams.* The following shall apply.

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

(1) not less than 75 mm below the underside of the roof or ceiling; and

(2) not more than as given in table 76 below the roof or ceiling; and

(3) not more than as given in table 76 below any exposed rafter or joist.

(b) *Sidewall sprinklers.* The deflector of a sidewall sprinkler shall be not less than 100 mm and not more than 150 mm below the ceiling.

COMMENTARY AND RECOMMENDATIONS ON 26.5.1.1. *Sprinklers located in the hottest gas layer, e.g.* 75 mm *to* 100 mm *below a flat ceiling, give faster response. It is for this reason that ceiling or flush, recessed and concealed sprinklers are not suitable for life safety applications.*

26.5.1.2 *Roofs and ceilings, with beams but without bays.* The following shall apply.

(a) *Sprinklers other than sidewall sprinklers.* Where a beam or joist is so deep that a sprinkler cannot be located below the beam or joist as specified in **26.5.1.1** it shall be located above the base of the beam or joist, at a distance below the ceiling as specified in **26.5.1.1**, at the appropriate horizontal distance as given in table 77 from the beam or joist.

Table 76. Maximum distance of non-sidewall sprinkler deflector below roof or ceiling

Type of construction	Measuring point	Maximum distance below measuring point
		mm
Plane surface roof or ceiling of combustible material or of asbestos cement sheeting, wired glass and similar frangible elements	Plane of underside of roof or ceiling	300, preferably 150
Combustible roof with exposed common rafters	Lower surface of rafters	150
Combustible ceiling with open joists	Lower surface of joists	150
Plane surface, non-combustible ceiling, not less than 75 mm thick	Plane of underside of ceiling	450, preferably 150
Arched non-combustible ceiling	Underside of crown of arch	450, preferably 150
Non-combustible ceiling less than 75 mm thick, affixed to underside of a floor with 2 h fire resistance	Plane of underside of ceiling	450, preferably 150
Non-combustible roof* and supports, excluding asbestos cement sheeting, wired glass and similar frangible elements	Plane of underside of ceiling	450, preferably 150

*A hollow block or concrete roof may be covered externally with a weatherproofing material, with or without a layer of heat-insulating material between it and the roof, provided that there is no intervening air space.

Table 77. Sprinkler location relative to beams and joists

Minimum horizontal distance from sprinkler vertical axis to side of beam or joist (see dimension *a* in figure 47)	Maximum height of sprinkler deflector above (+) or below (−) bottom of beam or joist (see dimension *b* in figure 47)			
	Conventional sprinkler		Spray sprinkler	
	Installed upright	Installed pendent	Installed upright	Installed pendent
mm	mm	mm	mm	mm
200	−20	See note 2	See note 2	See note 2
400	0	See note 2	0	0
600	+30	See note 2	+20	+60
800	+60	See note 2	+30	+120
1000	+100	−200	+50	+200
1200	+140	−170	+100	+280
1400	+190	−120	+130	+360
1600	+260	−30	+160	+470
1800	+390	+170	+180	+670

NOTE 1. Dimensions may be interpolated.

NOTE 2. Not applicable. These types are not used at these horizontal distances.

Table 78. Minimum distance of sidewall sprinklers from beams under flat ceilings

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

(b) *Sidewall sprinklers.* Any beam or other obstruction below the ceiling within a rectangle centred on the sprinkler, of dimensions $A \times 2B$ (see table 78) shall not exceed the depth given in table 78.

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

26.5.1.3 *Roofs and ceilings with bays and/or deep beams.* Where the depth of a beam or joist (see dimension *C* in figure 47) exceeds 300 mm for combustible ceilings or 450 mm for non-combustible ceilings, or other obstructions form ceiling bays so that the requirements of **26.5.1.1** and/or **26.5.1.2** cannot be met, then the obstruction or the beam or joist shall be regarded as a boundary.

COMMENTARY AND RECOMMENDATIONS ON 26.5.1.3. *Sprinkler protection of roofs and ceilings with beams or joists closer than* 1.8 m *centre to centre is not covered by this specification.*

26.5.2 *Columns*

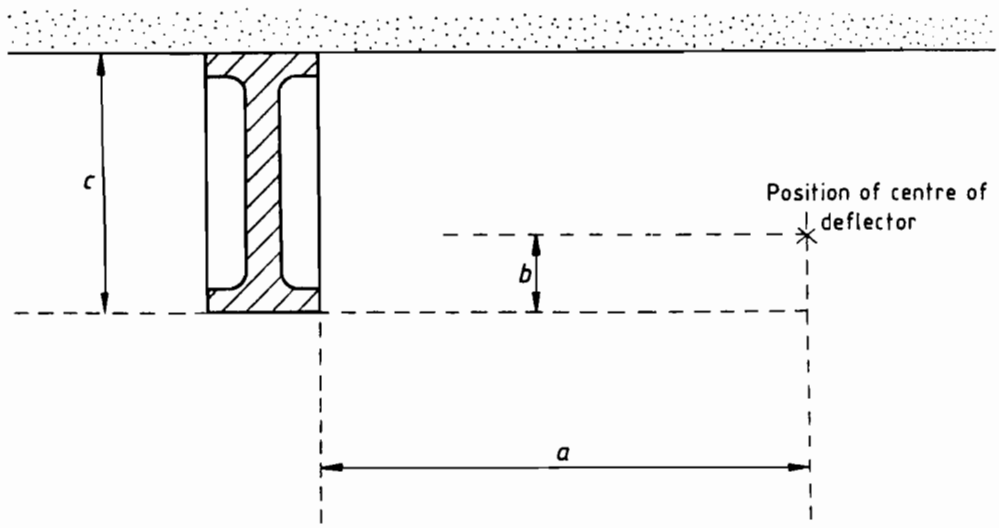
26.5.2.1 *General.* Where a roof or ceiling sprinkler is less than 0.6 m from the face of a column another sprinkler shall be located not more than 2.0 m from the opposite side of the column.

COMMENTARY AND RECOMMENDATIONS ON 26.5.2.1. *Sprinklers should be located as far as possible from columns.*

26.5.2.2 *High-piled storage, types S2, S3, S4, S5, S6 and S7.* Any column, of less than 2 h fire resistance, surrounded by high-piled storage of class S2, S3, S4, S5, S6 or S7, shall have provision for cooling spray from small orifice narrow angle sealed sprayers. There shall be one sprayer located on each side of the column at the level of the top of the storage with lower opposed pairs of sprayers, at intervals not exceeding 4.5 m, to the base of the column. Where there are obstructions to water downflow sprayers shall be located immediately below each obstruction.

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

COMMENTARY AND RECOMMENDATIONS ON 26.5.2.2. *The water for column protection is added to that required for the normal installation (see 15.1.2).*



Key:

a minimum horizontal distance
b distance of deflector above (+) or below (–) bottom of beam or joist
c depth of beam or joist

Figure 47. Sprinkler location relative to beams

26.5.3 *Girders*

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

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

26.5.4 *Roof trusses*

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

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

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

26.6 Concealed spaces

26.6.1 *Roof spaces.* Spaces between roofs and ceilings (including those at the apexes and sides of buildings) more than 0.8 m deep, measured between the highest point under the roof and the top of the ceiling, shall be sprinkler-protected.

26.6.2 *Intermediate floor spaces.* Concealed spaces between floors and ceilings shall be sprinkler-protected as follows:

(a) if any part of the concealed space is more than 0.8 m deep; and

(b) either;

(1) if they are not wholly of non-combustible construction; and/or

(2) if they contain combustible material.

26.6.3 *Space under lowest floor.* Sprinkler protection shall be installed in each space under the lowest floor in a building where the floor is combustible and:

(a) the space is accessible for storage purposes or entrance of unauthorized persons; and/or

(b) the space is not protected against accumulation of debris; and/or

(c) the space contains equipment such as steam pipes, electric wiring (except cables in conduit or mineral insulated copper-sheathed cables suitably earthed), shafting or conveyors; and/or

(d) the floor over the space is not sealed against liquid spillage; and/or

(e) flammable liquid is stored on the floor above.

26.6.4 *Cold-storage warehouses (air circulation refrigeration).* Sprinklers shall be fitted above any false ceiling within the cold chamber forming a plenum for the air circulating system.

COMMENTARY AND RECOMMENDATIONS ON 26.6.

Attention is drawn to the requirements of the Building Regulations 1985 which will apply to the construction of new buildings.

It is strongly recommended that suitable fire or draught stops be installed at approximately 15 m *intervals for horizontal division, and at each floor level for vertical division, in roof spaces and in concealed spaces between floors and ceilings not covered by 26.6.1 or 26.6.2 (i.e. not more than* 0.8 m *deep) where these are of combustible construction.*

See 24.1.4 for requirements relating to sprinkler protection in concealed spaces. See 26.9.3 for protection of voids above or below computer rooms.

26.7 Concealed spaces in plant

26.7.1 *Bins and silos.* Where practicable bins and silos, except as given in **4.2.1** (a), containing sawdust, wood flour, pulverized coal or similar easily ignited material which can be extinguished by water shall be internally protected by sprinklers.

COMMENTARY AND RECOMMENDATIONS ON 26.7.1. *Where the contents of bins or silos are liable to swell when wetted with the risk of bursting the container, the authority concerned should be consulted at the planning stage (see 3.1).*

26.7.2 *Corn, rice, provender and oil mills*

26.7.2.1 A sprinkler shall be fitted at the head of each dust trunk. Sprinklers shall be installed not more than 3.0 m apart in all dust trunks which are constructed of combustible material and which are installed more than 30 ° from the vertical.

26.7.2.2 Tiers of cyclones (centrifuges), or similar plant, separated by less than 1.0 m shall be protected by sprinklers located in the interspace as shown in figure 48.

26.7.3 *Elevators, rope or strap races, gearing boxes and dust receivers*

26.7.3.1 Elevators, other than pneumatic elevators or slow-moving endless chain, ring, loop or fork elevators capable of operating only when the elevator is full, shall be fitted with a sprinkler. The sprinkler shall be in the box at the top, located to discharge over the head and both legs or shafts of the elevator.

26.7.3.2 Rope or strap races, gearing boxes and enclosed belt or shaft machine drives of combustible construction or communicating between floors, shall be fitted with internal sprinklers.

26.7.3.3 Dust cyclones and dust collection chambers and boxes either inside the protected building, or outside and directly above any protected building with a combustible roof, shall be fitted with internal sprinklers.

COMMENTARY AND RECOMMENDATIONS ON 26.7.3.

Dust collection chambers and boxes not more than 10 m *from the protected building, and with trunking which runs to inside the protected building, should be sprinkler-protected.*

At least one sprinkler should be fitted inside trunking where it leaves the protected building to dust cyclones and dust collection chambers and boxes which are:

(a) above non-combustible roofs, or

(b) more than 10 m *from the protected building.*

26.7.4 *Escalators.* Sprinklers shall be installed:

(a) in the passenger carrying space; and

(b) below the ceiling below the escalator; and

(c) between the ceiling below the escalator and the passenger carrying space; and

(d) in the escalator boot; and

(e) in the motor space.

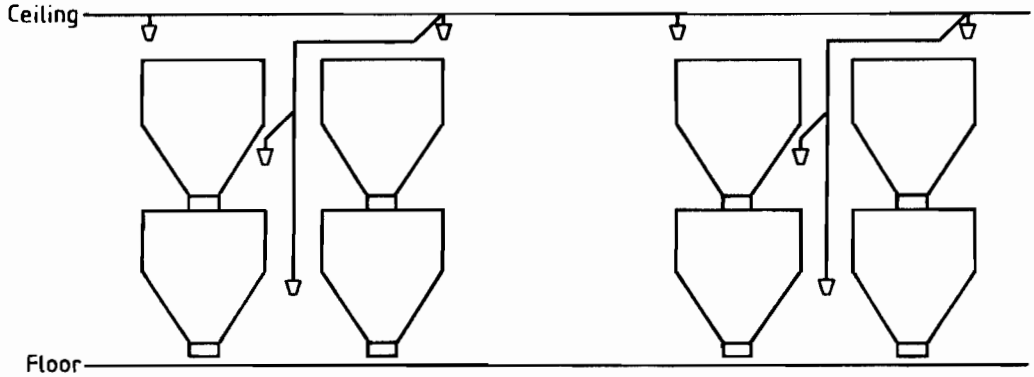


Figure 48. Protection of tiered conical plant, e.g. cyclone dust collectors

26.7.5 *Hoists, lift wells and enclosed chutes through floors.* Hoists, lift wells and enclosed chutes inside or in communication with sprinklered buildings, not covered by **4.2.2.1** (a), shall be fitted with sprinklers. Sprinklers at the head of lift wells shall be fitted with metal guards (see **25.8**).

COMMENTARY AND RECOMMENDATIONS ON 26.7.5.
Lifts complying with BS 5655 : Part 1 are covered by 4.2.2.1(a) and are therefore not required to be fitted with sprinklers, and that standard specifies that they shall not be fitted.

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

26.7.7 *Enclosed paint lines (enclosed), drying ovens and drying enclosures.* Sprinklers shall be provided inside enclosed paint lines, drying ovens and drying enclosures.

COMMENTARY AND RECOMMENDATIONS ON 26.7.7.
Sidewall sprinklers may be used for the protection (see 25.2.5).

26.8 Obstructions below sprinklers

26.8.1 *Platforms, heating panels etc.* Sprinklers shall be provided under the following:

(a) internal overhead platforms;

(b) heating panels;

(c) galleries;

(d) walkways;

(e) stagings other than in film or television studios (see **26.9.1**);

(f) stairs and stairways other than those exceptions covered by **4.2.2.1** (a);

(g) chutes;

which are either:

(1) more than 0.8 m wide and less than 150 mm from adjacent walls or partitions; or

(2) more than 1.0 m wide.

26.8.2 *Suspended ceilings*

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

26.8.2.2 *Suspended open ceilings.* The requirements of this specification shall not be applied where:

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

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

(c) the ceiling supports are combustible;

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

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

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

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

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

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

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

COMMENTARY AND RECOMMENDATIONS ON 26.8.2.2.
The design of sprinkler systems to protect buildings which do not meet (a) to (h) is outside the scope of this specification.

The ceiling should be of non-combustible construction and should not collapse before operation of the sprinklers.

See table 70 for sprinkler coverage where suspended ceilings may be used. See 26.4 for the clear space dimension to be maintained between sprinkler deflector and the top of the suspended ceiling.

26.8.3 *Ducts.* Sprinklers shall be fitted below ducts which are:

(a) rectangular and more than 0.8 m and less than 150 mm from adjacent walls or partitions; or

(b) circular and more than 1.0 m in diameter and less than 150 mm from adjacent walls or partitions; or

(c) rectangular and more than 1.0 m in width; or

(d) circular and more than 1.2 m in diameter.

26.8.4 *Hoods over papermaking machines.* The sprinklers shall be fitted under hoods or shields over the dry ends of papermaking machines.

COMMENTARY AND RECOMMENDATIONS ON 26.8.4.
Sidewall sprinklers may be used (see 25.2.5). See also 25.7.4.

26.8.5 *Storage racks.* Sprinklers shall be fitted to protect goods stored in racks.

COMMENTARY AND RECOMMENDATIONS ON 26.8.5.
See 26.1.4 for specific requirements relating to high-hazard occupancies.

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

26.9 Sprinkler location for specific hazards

26.9.1 *Film and television studios*

26.9.1.1 Sprinklers shall be fitted under

(a) solid or slatted platforms (except those used for temporary platforms etc. in connections with sets, but including those for lighting and other equipment) if these are more than 0.8 m wide; and

(b) walkways, connecting stairs, including those used for lighting or other equipment.

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

COMMENTARY AND RECOMMENDATIONS ON 26.9.1.2.
Any electric cables in the spaces should be run in screwed steel conduit or be of the mineral insulated metal sheathed type.

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

COMMENTARY AND RECOMMENDATIONS ON 26.9.2. *Where movable scenery is in use (for example under fly gallery floors) and there are projecting sprinklers particular care should be taken that the scenery can be moved safely and that the sprinklers are protected from damage. Sprinklers should be sited with particular care where personnel may work in close proximity for example under the grid, to reduce the risk of impact and injury.*

Stage floors are subject to frequent modification with some parts being removed and others replaced and account should be taken of this when sprinkler pipework is fitted under the stage.

26.9.3 *Computer areas.* In computer areas concealed spaces forming cableways not fitted with either a carbon dioxide total flooding system complying with BS 5306 : Part 4 or an automatic halon system complying with BS 5306 : Part 5 shall be fitted with sprinklers.

26.9.4 *Plastics roof lights.* Sprinklers shall not be installed directly below roof lights of PVC, or plastics of similar thermal behaviour and shall only be installed where:

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

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

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

COMMENTARY AND RECOMMENDATIONS ON 26.9.4.
The design of sprinkler systems to protect areas under plastics roof lights outside these limits is not covered by this specification.

27 Alarms and alarm devices

27.1 Water motor alarms

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

COMMENTARY AND RECOMMENDATIONS ON 27.1.1.
In addition hydraulic alarms may be fitted to subsidiary manual deluge installation control valves and as an option for subsidiary computer room protection.

See 20.1.5 for hydraulic alarm test valves.

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

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

27.1.3 *Pipework to water motor.* The pipework shall be galvanized, medium grade complying with BS 1387. The equivalent length of pipe between the alarm valve and the water motor shall be not more than 25 m assuming an equivalent length of 3 m for each change of direction. The nominal size shall be not less than:

15 mm for equivalent lengths less than or equal to 6 m; and

20 mm for equivalent lengths greater than 6 m.

The pipe shall be fitted with a stop valve located within the premises and shall be provided with a permanent drain through an orifice not larger than 3 mm diameter. The orifice plate may be integral with the pipe fitting, and shall be of either stainless steel or a non-ferrous material.

COMMENTARY AND RECOMMENDATIONS ON 27.1.3.
Non-corroding material is specified to avoid blockage by corrosion. The permanent drain should be situated in a frost-proof area, and should drain into a waste pipe tundish to avoid the danger of the drain pipe becoming blocked by ice. Care should be taken to avoid waste water discharge into the premises.

27.1.4 *Prevention of false and intermittent alarms.* Any device to reduce the frequency of false or intermittent alarms (see **2.37**) fitted to the installation shall be suitable for sprinkler service.

COMMENTARY AND RECOMMENDATIONS ON 27.1.4. *False alarms caused by wide fluctuations of town mains pressure may be prevented by the use of a retard chamber, or a jockey pump.*